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JPRS Report

Soviet Union

Economic Affairs

SPECIAL NOTICE

Effective 1 June 1987 JPRS reports will have a new cover design and color, and some reports will have a different title and format. Some of the color changes may be implemented earlier if existing supplies of stock are depleted.

The new cover colors will be as follows:

CHINA....................aqua
EAST EUROPE..............gold
SOVIET UNION.............salmon
EAST ASIA................yellow
NEAR EAST & SOUTH ASIA...blue
LATIN AMERICA............pink
WEST EUROPE..............ivory
AFRICA (SUB-SAHARA)......tan
SCIENCE & TECHNOLOGY.....gray
WORLDWIDES...............pewter

The changes that are of interest to readers of this report are as follows:

USSR reports will become SOVIET UNION reports.

The USSR REPORT: NATIONAL ECONOMY will be titled SOVIET UNION/ECONOMIC AFFAIRS (UEA).

The USSR REPORT: POLITICAL AND SOCIOLOGICAL AFFAIRS will be titled SOVIET UNION/POLITICAL AFFAIRS (UPA).

The following Soviet journals will be added to those which are already issued in separate series:

EKO: ECONOMICS & ORGANIZATION OF INDUSTRIAL PRODUCTION (UEO)
THE WORKING CLASS & THE CONTEMPORARY WORLD (UWC)
PEOPLES OF ASIA & AFRICA (UAA)
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AVIATION & COSMONAUTICS (UAC)
SOCIOLOGICAL STUDIES (USS)

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SOVIET UNION
ECONOMIC AFFAIRS

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GOSAGROPROM PRIVATE PLOT HEAD RESPONDS TO INQUIRIES

Moscow SELSKAYA ZHIZN in Russian 13 Mar 87 p 3

[Interview with N.S. Mukhin, chief of the section for subsidiary production and private plots of USSR Gosagroprom [State Agroindustrial Committee] by A Kostyukov; date and place not specified]

[Text] The chief of the section for subsidiary production and private plots of USSR Gosagroprom [State Agroindustrial Committee] N.S. Mukhin provides answers to questions sent in by readers of SELSKAYA ZHIZN.

[Question] Letters touching upon the problems of private plots serve as a type of news announcement. This is understandable in view of the fact that the busy gardening period is at hand. We are receiving a great amount of mail and certainly we are unable to mention all of the authors or examine all of the situations. Nikolay Stefanovich, could you not provide us with answers for the more typical questions? Some of our readers still do not fully understand the rights of citizens with regard to the use of private plots. True, we have only a few such letters."

[Answer] It is apparent from these letters that kolkhoz members, sovkhoz manual and office workers and the intelligentsia have been properly informed as a rule regarding their rights with respect to private plots. Questions are usually received in this regard from citizens who live in rural areas but work on the side. This is typical of suburban regions. For example, let us take a teacher who lives on a sovkhoz in Kamensko-Dneprovskiy Rayon in Zaporozhye Oblast (she requested that her name not be mentioned) and works at a municipal motor transport enterprise. The sovkhoz board of directors refused to grant her a private plot. Is this legal?

If an individual who resides in a rural area works at an enterprise or for an organization or institute which is associated with agriculture or which provides services for the rural population (these are enterprises, organizations or institutes which are set forth in special lists), then the farm on the territory of which he lives is obligated to provide him with a plot measuring up to 15 one hundredths of a hectare in size. Kolkhozes, sovkhozes and other agricultural enterprises are not obligated to make garden tracts available to workers who live in rural areas but who work for other production operations (industry, transport and others). However, they are

authorized to do so if free land from the private plot fund is available to them.

[Question] Many arguments arise concerning the private plots. It sometimes happens that a situation raised in the form of a discussion is accepted by the readers as a legal norm. In this regard, L. Yeroshenko in Rostov Oblast, V. Patsyuk in Dnepropetrovsk Oblast and some others have asked whether or not the former restrictions with regard to the size of a private plot or hothouse or the number of animals on a private plot still remain in force or have they been revised.

[Answer] First, allow me to mention the hothouses. Their maximum area -- 20 square meters -- was earlier defined in the construction norms and rules and approved by USSR Gosstroy. New SNiP's [construction norms and regulations] were introduced in July 1986 in which the maximum dimensions for hothouses were not established. Today they are determined by the general building plan for a tract issued by a rayon architect and, similar to all other buildings, they are erected in conformity with the plan.

No other changes have been introduced in connection with the use of private plots. The USSR Principles of Land Legislation and the Model Kolkhoz Regulations establish the maximum area for private land utilization by residents: up to .5 of a hectare for non-irrigated and up to .2 of a hectare for irrigated land. Specifically, a garden area for a family is controlled by the Kolkhoz Regulations or the decisions handed down by a sovkhoz administration or local soviets depending upon a family's participation in kolkhoz-sovkhoz production and the size of the family. In cities and settlements of the municipal type, the size of a private plot can range from .03 to .12 of a hectare.

The number of animals which the family of a kolkhoz member is allowed to maintain is also defined in the Kolkhoz Regulations. The norms for the maintenance of privately owned livestock by citizens who are not members of kolkhozes and who reside in rural areas or in cities or worker settlements are established by the union republic supreme soviets and remain unchanged.

[Question] Krasnodar residents A. Popov and A. Tokarev asked a question which appears quite often in our letters: must a citizen operate a single-crop system on his private garden or is he free to cultivate whatever he chooses?

[Answer] There are no legal documents which stipulate how many crops are to be grown -- two or twenty. This is the concern of the operator of the plot. But at the same time it must be remembered that the auxiliary nature of a private plot is emphasized in all documents having to do with the private economy. In other words, the principal purpose of such a plot is to satisfy the requirements of the owner for the products needed.

[Question] A majority of the letters selected by us (particularly the letters sent in by A. Kosinova in Kursk Oblast, R. Potemkina in Kaliningrad Oblast and N. Gnida in Sumy Oblast) contain a request for a clearer definition of the responsibility of a kolkhoz or sovkhoz with regard to supplying the owner of a

private plot with feed, irrigation water, equipment, fertilizer, grazing land and so forth.

[Answer] In the decree handed down by the CPSU Central Committee and the USSR Council of Ministers entitled "Further Improvements in the Economic Mechanism for Management Within the Country's Agro-Industrial Complex," the responsibilities of agricultural enterprises with regard to supplying the operators of private plots with dairy cattle, poultry and feed and furnishing them with technical assistance are pointed out. Emphasis is placed upon the fact that all of this work must be set forth in the financial plans for the kolkhozes and sovkhozes, that is, it must all be planned. It is believed that all of this has been stated quite clearly.

However, the authors of some letters maintain that there is no document which specifically sets forth how many hundredths of a hectare of pasture or how many quintals of grain a kolkhoz is obligated to allocate per head of privately owned livestock or how much fertilizer is to be sold. There truly are no set figures for doing this. Imagine for yourself the diverse conditions under which 50,000 kolkhozes and sovkhozes are operating throughout the country and you will understand why it is hardly possible to develop standard norms for all situations. In Kazakhstan, for example, there are tens of millions of hectares of pasture land and yet the Kuban stations are plowed only around the outskirts. Under such conditions, how is it possible to establish a uniform grazing land norm for them?

And generally speaking, should such problems be resolved by means of the directive method and invariably in Moscow? This question is particularly pertinent at the present time, when in all spheres of life we are attempting to rely upon the principles of self-government. The responsibilities of public farms with respect to the private plots of kolkhoz members can and must be legalized during their own general meetings and those of sovkhoz workers -- in collective agreements. A decision adopted by a collective will in all probability be correct.

Today many farms are concluding agreements with the owners of private plots for the production of goods for sale to consumer cooperative organizations and to kolkhozes and sovkhozes. This is fine work. But examples are being cited in the letters of a careless attitude by some farm leaders towards their contractual obligations. Such violations must be punished -- this is called for by law.

[Question] The sale of mixed feed is deserving of special mention. All winter we have been hearing complaints: the readers maintain that they are entitled to be supplied with mixed feed and yet the feed is nowhere to be found. This was the position taken in recent letters received from G. Voytenko in Dzhizak Oblast and B. Drizhka in Krasnodar Kray.

[Answer] Last year, 4.4 million tons of mixed feed were allocated for sale to the population and this year the figure has been increased to 5.5 million tons. But the readers are correct: this is a small amount. Actually, the

state is certainly acting in a stingy manner -- similar to grain feeds, there is simply a shortage of mixed feed.

[Question] A letter has just been received from M. Goloshubov in Volgograd Oblast. In it the author describes a rather rare situation: the board of directors of a sovkhoz promises the owners of private livestock with assistance in the form of feed only upon the condition that they supply the sovkhoz with meat and milk and only the sovkhoz. Is this requirement legal?

[Answer] This question is being asked in many of the letters which we are receiving. The products produced on a private plot are the property of its owner. He is free to dispose of these products as he wishes. The fact that he delivers a young bull to cooperation specialists or sells it on the market is not cause for the kolkhoz or sovkhoz to refuse to provide him with grazing or haying land. The only exceptions are those times when a young bull has been fattened on the basis of an agreement with a farm and the farm carried out its contractual obligations. An agreement is an agreement and it must be observed by both sides.

In passing, I will respond to those readers who do not fully understand the difference between a private plot and a family contract. The difference lies in the fact that the tract of land and the livestock, feed and other means of production allocated to a family that signed a contract and also the products produced by it belong completely to the kolkhoz or sovkhoz. For its work, a family receives, as called for in the contract, a monetary payment or money plus a payment in kind. Understandable, such a family is provided with the resources required for production under different conditions than those associated with the management of a private plot.

[Question] Letters sent in by A. Staropakhatniy in Gomel Oblast, N. Matyunina in Kuybyshev Oblast and many others recall to mind the obligations which a private plot owner has towards a public farm. And a kolkhoz or sovkhoz is justified in undertaking measures against those who neglect these obligations.

[Answer] The principal obligation of any able-bodied kolkhoz member or sovkhoz manual or office worker is that of carrying out conscientious work in public production. I have already stated that the size of a private plot is determined in particular by the amount of labor participation by a family in the affairs of a kolkhoz or sovkhoz. The size of the area could fluctuate from 15 to 50 one-hundredths of a hectare depending upon this factor. If a worker systematically violates the Kolkhoz Regulations, labor legislation and the work schedule adopted on a farm and if he blatantly declines to work in the public sector, his private plot could be reduced in size and he could be deprived of the right to use irrigation water, grazing or pasture land for his privately owned livestock, transport and other items of technical equipment on the basis of decisions handed down during a general meeting of kolkhoz members and the sovkhoz administration acting in concert with the trade union committee.

Unfortunately, the agricultural leaders often resort to the use of illegal sanctions -- the destruction of crops, a prohibition against shipping products to market and others. These actions are illegal and must be terminated. Those who truly wish to organize equitable and mutually advantageous collaboration between the private and public sectors have adequate laws at their disposal for regulating their relationships.

7026
CSO: 1824/202

KaSSR DEPUTY MINISTER ON WHOLESALE TRADE IMPROVEMENTS

Alma-Ata NARODNOYE KHOZYAYSTVO KAZAKHSTANA in Russian No 1, Jan 87 pp 23-25

[Article by R. Nurumova, deputy minister of trade of the Kazakh SSR: "We Are Improving the Management of Wholesale Trade"]

[Text] The level of supply of nonfood goods has risen in the republic in recent years. Cotton fabrics and many types of cotton clothing, socks and stockings, soap and detergents, garden equipment, television sets, tape recorders, clocks, and refrigerators are no longer in short supply. These changes can only be welcomed. However, saturating the market with nonfood goods raises and makes paramount the critical problems of quality and assortment.

Of course, the first word in solving the problem of quality goes to industry. But a great deal also depends on how active the trade system is, especially its wholesale element.

One of the primary challenges of the wholesale system today is to give industry correct guidance based on studying consumer demand. To do this all wholesale offices have set up special services which include, in addition to released employees, specialists from the commercial and planning subdivisions. Similar services are being set up at wholesale depots and retail trade organizations. There are about 400 subdivisions to organize this work in just the republic's state trade system.

All the same, there are still serious shortcomings in studying demand for consumer goods.

We link significant improvement in the organizational and methodological level of this work with devising and introducing the SKIPS [system for comprehensive study and forecasting of demand] system. Obtaining reliable information will make it possible to reach sound planning and management decisions. Experimental industrial use of the SKIPS in several republics of the country has shown that it intensifies the influence of trade on industry for the purpose of more fully satisfying buyer desires.

In our republic work to introduce the SKIPS began in 1985 with men's suits. In the 12th Five-Year Plan 140 goods categories will be brought into the system.

The SKIPS is being introduced at organizations and enterprises of trade and industry. But the wholesale element should carry the primary load in this work. It is the one that is given responsibility for correctly determining the need for goods, buying the right assortment and quality, and supplying them to the retail network in conformity with popular demand and without interruptions.

The program for industrial introduction of the SKIPS envisions broad use of modern computer equipment on the basis of existing ASU's [automated data processing systems] and computing centers. Orders from trade and the results of wholesale fairs, of course, will be the basis on which the production associations (enterprises) of all sectors of the economy develop their plans for production of consumer goods. The new system will require a great deal of work to strengthen the mutual relations of trade and industry, in particular to refine the fair mechanism.

Things must be set up in such a way that trade organizations at wholesale fairs actually deal with the suppliers, that they select and order only those goods that will find buyers and will not lie unwanted on the racks at warehouses and stores. The work with industry at trade fairs should become the basis for development of purposeful trade-assortment policies aimed at specific consumers.

The document "Fundamental Directions of Economic and Social Development of the USSR in 1986-1990 and the Period Until the Year 2000," which was ratified by the 27th CPSU Congress, follows a target-program approach to the problem of better meeting the needs of Soviet people for consumer goods.

In conformity with the decisions of the congress the republic has adopted a policy of rationalization and specialization of the trade network through implementation of comprehensive territorial, intersectorial programs. To organize this work the KaSSR Ministry of Trade has formed a technological council, set up a center to introduce scientific-technical advances and rationalize trade and public catering, and ratified a program to accelerate scientific-technical progress in the sector. In addition, there will be further development of the republic's retail trade enterprises, the department stores, large specialized stores that sell goods from light industry and highly technical items, and self-service stores where the customer can buy a broad assortment of everyday necessities, notions, and household items in addition to food.

During the 12th Five-Year Plan more than 230,000 square meters of trading area will be put into use in just the cities and worker communities of Kazakhstan, including 3 department stores (the largest, 15,000 square meters, in Alma-Ata) and 50 self-service stores; more than 1,600 stores will operate using the new supply technology with packaging equipment.

In light of the challenges that have been posed there will have to be a radical improvement in the management of wholesale trade. In this connection a policy of significantly increasing wholesale trade turnover has been adopted. Special attention will be given to warehouse turnover and concentrating stocks of goods mainly in the wholesale element, which will make it possible to carry out timely maneuvers with stocks of goods.

It is not possible to meet the challenges given to the wholesale element without development of its material-technical base. During the 11th Five-Year Plan alone the growth in general goods warehouses in state trade was more than 146,000 square meters (about 12 percent of the 1980 figure) and refrigeration capacity increased by almost 28,000 tons (more than 30 percent of 1980).

The general goods warehouse space available in the republic per capita in the cities and worker communities rose by 1986 to 87 percent compared to 78 percent at the start of the five-year plan, and for refrigeration units the figure was 79 percent compared to 61.2 percent. And these indicators are slightly higher than the USSR averages. Modern refrigeration units with new equipment were put into operation in Alma-Ata and Guryev and general goods warehouses were opened in Temirtau, Kokchetav, Taldy-Kurgan, and Alma-Ata. Just three republic offices (Kazgalantereytorg [notions], Kazkhoztorg [household goods], and Kazobuvtorg [footwear]) built about 30,000 square meters of warehouses in 1981-1985 using State Bank credit and the trade development fund.

Building up the wholesale system's material-technical base made it possible to improve goods supply to the retail system. In the 12th Five-Year Plan we will continue work to strengthen the material-technical base of wholesale depots. Thus, in 1986-1990 we plan to use state capital investment capital to put 55,500 square meters of general goods warehouses and 35,000 tons of refrigeration unit capacity into operation. In addition, the republic Ministry of Trade will use bank credit vigorously every year to renovate and rebuild the material base of wholesale organizations.

We must note, however, that existing warehouse area is by no means used fully everywhere in the wholesale element. Thus, the findings of a survey by VNIIEKTsistem [possibly All-Union Scientific Research and Experimental Design Institute of Trade Systems] showed that the capacities of warehouses for the operations of receiving, storing, batching, and shipping goods overall (with the exception of storage areas less than 4.5 meters high) are only used at a 60 percent level.

Here is another example. Whereas stocks of goods in the retail system of state trade on 1 January 1986 were 1.74 billion rubles (68 days), wholesale depots of the republic Ministry of Trade has just 1,073.4 billion rubles (48 days), or just 38 percent of the total volume.

So when talking about successes and plans for the future, we do not close our eyes to shortcomings in our own work. To correct the situation we have adopted a policy of concentrating stocks of goods primarily at wholesale trade warehouses.

Solving this problem will, of course, demand more efficient use of the capacities of existing general goods warehouses, which involves switching to progressive technologies for delivering, storing, and selling goods and the use of more technical equipment. After all, while the level of mechanization of labor at warehouses of the republic's wholesale offices at present is just 35 percent, at certain refrigeration units that use packaged and stackd freiight this indiciator surpasses the overall figure by 80 percent.

Naturally this situation does not suit us. And steps have already been taken to produce 30,000 units of packaging equipment a year at the Alma-Ata Trade Equipment Plant and enterprises of the Kaztorgmontazh Trust. Using this equipment for warehouse work and delivery to the traderooms of various kinds of food stores packed in bottles, glass and tin cans, boxes, stacks, and packs) and for everyday nonfood goods (soaps, detergents, electric lights, paints, garden tools, notebooks, metal pots and pans, and so on) will make it possible to reduce the large number of unproductive operations and eliminate many transshipments of goods.

Furthermore, enterprises of the Kaztorgmontazh [trade equipment installation] Trust have set up facilities to produce 800 freight-hoisting carts a year and organized an experimental workshop that can fabricate mechanization equipment worth 500,000 rubles a year. Thus, in 1986 this workshop made new types of racks and stanchioned pallets for storing textile goods and television sets for the warehouses of the Alma-Ata depots of Kaztekstiltorg [textiles] and Kazkulttorg [cultural goods]. This will make it possible to raise the efficiency of use of warehouse capacities and to mechanize loading-unloading work.

Under conditions where the mass of goods has increased and warehouse capacities are inadequate the process of transforming the industrial assortment into a trade assortment has become much more complex. Therefore, wholesale organizations are trying to increase direct, so-called transit, deliveries to retail enterprises, switching their functions of goods supply, sorting, and storage to the retail organizations. This practice must be firmly rejected, because it often leads to uneven distribution of stocks of goods among stores, to breakdowns in trade in everyday necessities and in the adequacy of the assortment, to goods delivered in excess quantities and unsold becoming unsalable, and to an increase in the level of handling costs.

There are other problems as well. The existing lack of coordination between evaluation indicators for the activities of the wholesale and retail systems lessens the role and accountability of wholesale trade for the organization of goods supply and fulfillment of the plan of retail trade. The contradictory tasks given to the wholesale and retail systems exacerbate their mutual relations, which in turn cannot help affecting the results of the work of the sector as a whole. All this demands that we search for new organizational forms and ways of improving sector management.

One of the best solutions, in our view, is the formation of wholsale-retail associations at the republic and oblast level. What does this do? Above all it gives maximum concentration of goods sales, a reduction in stocks of goods

at the stores, a decrease in the costs of handling them, and preservation of the bulk of seasonal goods at wholesale warehouses.

The republic has already accumulated some experience with the work of such associations. For example, the Zarya Wholesale-Retail Association for footwear trade is already operating successfully in Alma-Ata. More than 70 percent of market resources of footwear are sold through this association's stores, and it is especially important that they have practically no unsalable and long-unsold goods. The trade process is organized on the self-service principle in all this association's stores. All this was possible thanks to close contacts between trade and industry in broadening the assortment and improving the quality of footwear.

The republic Sporttovary [sporting goods] Wholesale-Retail Association, which was formed in 1979, and its eight subordinate oblast associations have increased the volume of retail trade 2.2 times in their 7 years of existence, while wholesale trade has gone up 2.4 times and the concentration of sales of goods is 70 percent.

The accountability of wholesale employees for supporting the retail trade plan and for saturating the stores with everyday goods in an adequate assortment has been increased. The fact is that their wages are made directly dependent on these indicators.

In the 12th Five-Year Plan we will continue work in the republic Ministry of Trade system to set up republic and oblast wholesale-retail associations for trade in footwear, lumber and building materials, and furniture; this will unquestionably help satisfy public demand more fully.

It must be stipulated, however, that under our republic's conditions, considering the list of goods, setting up wholesale-retail associations is not always advisable for all other commodity groups. For this reason the wholesale organizations continue to face the critical tasks of more correct distribution of goods by regions and trade organizations; shifting above-norm stocks; packaging individual footstuffs, and the like.

We are now increasing the personal accountability of managers and specialists at wholesale organizations for cases where consumer goods, everyday necessities, and goods for children, young people, and elderly people are not available for sale, for performance of delivery contracts concluded with industry by time, volume, and assortment of goods, and for reinforcing control of the quality of output being received. To accomplish this;, among other steps, assignments have been established to set up dispatcher offices and introduce the Ritm system at oblast wholesale depots, which will make it possible to ensure timely delivery and sorting of goods for the retail system. We are employing this system at a number of depots of the republic offices -- Kazxgalantereytorg, Kazkhoztorg, Kazobuvtorg, and Kaxtekstiltorg -- and it has proven itself fully.

The dispatcher offices at wholesale depots ensure timely shipment of goods to the stores, inform the retail system of the receipt and availability of goods at the depots, and monitor the work of vehicle transportation, which makes it

possible to maintain a stable assortment and eliminate interruptions in trade quickly.

Growth in the volume of trade, expansion of the trade network, and the need for effective influence on the supply of goods to the stores demanded that information-dispatcher offices be established at the level of the oblast trade administrations also. These offices, equipped with radio and telephone communication and having access to computers at computing centers, are now operating in Tselinograd, Karaganda, Chimkent, and Alma-Ata. The dispatcher offices at wholesale depots have also become an essential element.

The restructuring of the sector's economic mechanism poses new challenges for trade. We will have to modify the entire way in which financial resources are formed and used and ensure the transition to self-financing principles.

11176
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STRATEGIES FOR LONG RANGE ENERGY DEVELOPMENT

Moscow EKONOMIKA I MATEMATICHESKIYE METODY in Russian Vol 23, No 1, Jan-Feb 87 pp 25-37

[Article by A. A. Makarov (Moscow): "Boundary Strategies for Long-Range Energetics ('Energetika'); passages within slantlines published in italics]

[Text] 1. The Scientific Grounds for Long-Term Energetics Forecasting

Development of the USSR's Energetics Program for the long term and its periodic refinement and supplementation and work conducted systematically in accordance with the Comprehensive Program for Scientific and Technical Progress and with schemes for developing the fuel and power branches (within the framework of the Master Scheme for Developing and Distributing the Productive Forces)--all this research requires, first, careful collaboration and coordination and, second, a unified and scientifically sound concept for developing the energy activity.

In order to create such a concept, above all comprehension of the natural-science ideas that form the basis for foreseeing future energy development is required. Five groups of such ideas can now be singled out.

The basic LAWS OF THE CONSERVATION OF MATTER AND ENERGY comprise the first and most reliable group. When forecasting energy activity, these laws are stated in the form of prerequisites for balancing the production and consumption of each type of energy with the material resources and should be observed at all stages in the transformation of energy and in the regional aspect. A developed system of material and energy balances is a powerful means for determining the future which outlines the area of the realistic potential for development. But by no means does it provide unambiguous guidance to paths for future energy development or, at times, even a glimpse of it within an acceptable spectrum. This is caused by the fact that each prerequisite for a balance is expressed quantitatively through numerous technological, social and economic indicators over broad intervals of possible values.

The second group consists of THE WHOLE ASSEMBLAGE OF PHYSICAL, CHEMICAL AND BIOLOGICAL LAWS AND PRINCIPLES. These include the laws of mechanics, electrophysics, hydraulics and heat physics--for example, Kirkhhoff's laws for electric current in complex circuits, restrictions on the efficiency factor

that are determined by the Carnot cycle, and so on. Many hundreds of such interrelationships make up the basis for determining future technological and, to some extent, economic indicators for the energy activity. But even for technological indicators, this group determines not an unambiguous dynamic of future values or intervals, or even just the theoretical (ordinarily the lower) limit of their possible range.

THE PRINCIPLES OF USING NATURAL RESOURCES, whose reserves by region and for the earth as a whole are basically limited and at each moment of time are partially explored, form the third group of natural-science ideas. Mathemetical statistics that concern the data of geological science yield a quantitative description of the dynamics of extracting such resources as a process of arbitrary gathering without being replaced. But the overall geological reserves of each energy resource and the pace of scientific and technical progress in exploring for it and in extracting it must be known for this purpose. Meanwhile assessments of the overall reserves of the resources are periodically refined and can change radically (severalfold) with the appearance of new geological prospects. Scientific and technical progress in developing and in extracting natural resources have still less predictable consequences. Therefore, it is not possible, even on this basis, to get a forecast of energy-resources production that is reliable enough.

The fourth group includes THE PROPERTY OF THE SLUGGISHNESS OF LARGE SYSTEMS AND OF THE COMPLEX PROCESSES THAT OCCUR IN THEM. The bases here are the delays in executing all types of cause-and-effect relationships and also the resistance to the changes that always arise in large developing systems (homeostasis).

The sluggishness of development of the systems can be described directly and indirectly. In a direct description, the balancing conditions that flow from the laws of the conservation of matter and energy are verified for each time stage examined, and beyond that they also describe, in the form of balances of capacity the vital cycle of the elements and the reproduction dynamics of the structure of the system being forecast. This reduces considerably, but by no means eliminates, indeterminacy in foreseeing the future in comparison with the use of some laws of the conservation of matter and energy alone.

An indirect description of the sluggishness of development processes is based upon the discovery of unclear mutual relationships in change of the various parameters or factors of development of the system being analyzed. Depending upon their nature, it is useful to distinguish the following forms of unclear description of stable mutual relationships that are stimulated by sluggishness in the development of large systems:

statistical functions for which the form of the function that describes them and its quantitative parameters remain unchanged at only a comparatively brief stage of development;

functions that reflect objective tendencies, for which the form of the function that describes them is preserved throughout the whole period of observation but lacks a full theoretical explanation of the relationship observed, yet the function's parameters usually vary with time;* and

principles that derive completely from precisely formulated postulates and have an unambiguous form of function with parameter values that are constant in time.

It is clear that statistical functions are used in short-term prognoses but have practically no value for long-term forecasting. Functions that reflect objective tendencies are more suitable for foreseeing the remote future, but questions of the permissible periods of their effect and of the future values of the parameters of the corresponding functions always arise. Yet only consistencies can be used with confidence in long-term forecasting of energy development.

Thus the sluggishness characteristic has limited effect. For such large systems as energy, it, together with the three other groups of ideas, can enable the future to be determined for the relatively short period (5-10 years) that is necessary for practical purposes, when the action of most of the functions that reflect objective trends, and even of many of the statistical relationships among the parameters and factors for developing the system, is preserved. In the medium term (less than 15-20 years), and especially for the long term, only the action of strict principles of development and of functions that reflect certain especially long-term objective tendencies is preserved. That is why the discovery and study of them have such great importance for forecasting the development of energetics.

The fifth group of natural-science ideas that yield a basis for foreseeing the future can include THE PRINCIPLE OF THE LEAST ACTION, which creates a natural-science basis for choosing effective (in the cosmological, not the narrowly economic sense) paths for developing the energy activity. The principle of the least action determines the most important properties of the dynamics of the engineering physics of energy systems (for example, the characteristics of the processes that proceed in electrical and hydraulic circuits are described by Kirkhhoff's laws, Maxwell's equations, and so on). Indirectly, it apparently also forms criteria for the optimality of complicated production and, in particular, of energy systems. For example, one can see a parallel between the principle of least action and the Marxist law of the saving of live and embodied labor in the labor theory of value. It is precisely the principle of the least action that is kept in mind later, when choice of a group of effective trajectories--strategies for developing energy--becomes necessary.

The main difficulty in developing a reliable long-term forecast for such a large sphere of the national economy as energy is caused by the great influence on the long-term dynamics of its development of, in additional to the natural-sciences ideas named, socio-economic factors. It is the socio-economic factors that govern the creative efforts and successes of society in the area of scientific and technical progress, that govern the rate of growth of labor productivity and development of the economy, and through them, the dimensions and structure of energy consumption, and, consequently the required amounts, and at the same time, the potential for producing energy resources.

Science does not now have at its disposal reliable means for predicting specific quantitative evaluations of the effect of socio-economic factors over

the long term. Therefore, a great and still unavoidable indeterminacy of a fundamental nature, which precludes the possibility of seeing the distant future with certainty, not only unambiguously but even at acceptable intervals, is introduced into the action of the laws, properties, and so on, of the five named groups of ideas. Given the present state of knowledge, only a "cone" of possible strategies for developing the energy activity, which is expanding rapidly with time, can be determined objectively.

Recognition of the existence of such a "cone" of strategies as the sole objectively accessible and yet scientifically validated result of a long-term forecast would be incorrectly interpreted as a lack of commitment to or a rejection of the long-term development of the energy activity. A constructive result of what has been said is the clear but unspoken acknowledgement of the necessity for introducing into the long-term forecast precise and specific objectives, which will permit a narrow "bunch" of trajectories, that is, a definite strategy for developing the energy activity that is satisfactory for practical purposes, to be chosen from the blurred "cone" of scientifically validated possibilities.

Such specific objectives should be determined by the laws of social development (in particular, by the basic laws of socialism) and given specificity in relation to the energy activity by the top level of the hierarchy of large systems, that is, by the hierarchy of the national economy as a whole. The purposes of its development are established by the country's political leadership, based upon an understanding of the task of social development that has taken shape at that level. In our opinion, only in this way can socio-economic factors be considered in the "cone" of natural-sciences notions about the possibilities for long-term development of energy at the modern level of development of the social sciences. Attempts to do so on the basis of subjective assessments of the socio-economic purposes for developing various forecasts (or a collection of them) is not, in our opinion, constructive, since the purposes chosen for development should be reinforced by the corresponding potential and rights and by firm decisiveness to achieve them.

Thus, scientific forecasting of future development of the energy activity falls, methodologically, into two mutually connected but essentially different processes:

the FORECASTING proper, which has the purpose of outlining the bounds of the "cone" of natural-sciences ideas about the possibilities of long-term energy development; and

the FORMULATION, based upon socio-economic policy, of SPECIFIC OBJECTIVES for developing the energy activity, and the selection, based thereon, from a broad "cone" of possibilities, of a definite energy strategy with its quantitative characteristics.

Work on refinement and supplementation of the USSR Energetics Program over the long term is being construed in about the same way. Proceeding from socio-political objectives, requirements are formulated in order to support development of the country's economy at a definite annual average rate of growth in national income and welfare of the people, as well as the export of energy resources to CEMA member countries. By means of special studies based upon interbranch models of the economy, specific tasks are defined for:

labor productivity growth by increasing the ratio of electrical and mechanical equipment to workers; energy saving and, consequently, energy consumption; the maximum share of capital investment for developing the fuel and power complex in overall capital investment in the national economy; and increase in currency receipts from the export of energy resources. These specific objectives determine very rigidly the strategy for energy development and, in essence, define it unambiguously within the broad "cone" of possibilities.

The methodological concept of the long-term forecasting of energy development that is being examined, which combines study of the "cone" of possibilities with the forming "from the top" of specific objectives for developing the energy activity, is feasible only over a period of 15-20 years. During this time the government-regulated system of preplan development that is in operation will enable a long-term socio-economic policy of the state to be formulated with precision and the objectives (tasks) for developing energy to be spelled out in detail.

Such work still is not being conducted for the more distant future. Meanwhile, the high state of sluggishness of the energy branches requires that a much longer term (up to 30-40 years) be examined, in orde to substantiate correctness of the decisions that are planned for realization within the next 15-20 years. Among them are decisions on the levels of recovery of oil, gas and coal of the main basins that are to be maintained for a maximum time period, on the ecological consequences of developing the energy activity and their influence on the regional siting of the productive forces, on the fuel cycle and safety of nuclear power, and so on.

Without specific official socio-economic objectives, scientific substantiation of the indicated solutions actually comes down to substantiating them within the limits of the whole "cone" of possible strategies for developing energy. Of course, this considerably increases indeterminacy of the conditions for adopting specific decisions, but it corresponds to the objective level of our knowledge about the future. Moreover, as indicated above, even such blurred notions about the future give enough information for assessing the assignment of priorities for the basic solutions for developing energetics.

A study of the "cone" of objective possibilities for developing energetics falls, in our opinion, into three stages:

determination of the so-called boundary strategies, exceeding the limits of which within the period being examined is impossible or extremely unlikely;

discovery of the internal structure of the "cone" of objective possibilities, that is, of complexes of strategies that are close in essence, which meet the various possible prerequisites for developing energetics; and

disclosure, within the framework of each such complex of strategies, of the potential for a more fundamental hierarchy of trajectories for developing the various portions of the energy activity.

It is clear that a full study of the "cone" of possibilities, especially within the framework of the third stage, is not a near-term matter. Up to the present it has been posssible:

to establish the composition of the main factors that determine long-term energy development;

to assess the limits of change of these factors and a quantitative measure of their influence upon the consumption and production of energy resources;

to discover the extreme trajectories of change of the chief quantitative characteristics for long-term energy development that have been caused by the basic factors obtained; and

to make up boundary strategies for developing energetics from these strategies by balancing them.

Execution of the corresponding multiple-factor research for the long-term development of energetics required the development of a special tool in the form of a simulated interactive system for the long-term development of energetics which would permit the work necessary for the long term, up to the years 2040-2050, to be done within acceptable periods.

2. The Task of Studying Boundary Strategies for Developing Energetics

Those paths for development under which the main indicators that describe the dynamics of consumption and production of energy resources are positioned at the bounds of the "cone" of objective possibilities for developing energetics are naturally called boundary strategies. This formulation does not pretend to be complete or rigorous. It does not, in the first place, define the composition of the main characteristics of the dynamics for developing energetics, and, second, a simple form of the bounds of the "cone" of possibilities, for example, in the form of an upper (accelerated) and a lower (slowed) trajectory of development, is assumed in an unclear fashion. In actuality, the dynamics of a whole hierarchy of successively detailed indicators characterizes energetics development, and the level to which it is permissible to descend during long-range forecasting is still to be established. The bounds of the "cone" of possibilities, by virtue of the abundance of indicators that characterize each trajectory of energetics development, obviously are multivariate. Therefore, they can be found only as a result of special study.

The conceptual distinction between a study of boundary strategies for developing the energy activity and the numerous works produced in the last decade that studied alternative scenarios for developing the energy of the world or of individual countries must be emphasized. In developing alternative scenarios, it is not proposed that the whole "cone" of possibilities be studied. Therefore, they are formulated primarily by direct selection of several variants of consumption and production of energy resources--as a whole and by type. In studying boundary strategies, the main task is to determine the role (the range in change and degree of effect) of the qualitative indicators upon which energetics development depends, and to find trajectories that correspond to boundary values of the more significant of these indicators. Such an approach is richer by far than the study of two or three alternative scenarios and is actually capable of outlining the bounds of a multivariate "cone" of possibilities.

We illustrate the meaning of the difference of the two approaches in an arbitrary example (figure 1). The thick lines there represent the generalized results of a computation of energy-development indicators under two alternative scenarios: the first, which corresponds to an extremely pessimistic concept of reduction in the average annual rate of growth of national income, and the second, which corresponds to the concept of increasing the annual average rate of growth of national income when more intensive energy-saving policies are implemented, the development of electrification is being accelerated, the levels of recovery of hydrocarbon fuel are raised, and the development of nuclear power is considerably more rapid. The increase in recovery of oil and gas and the acceleration in developing nuclear power in this scenario are explained by the potential for the supplemental financing of these branches (including geological exploration) when the pace of economic growth is accelerated.

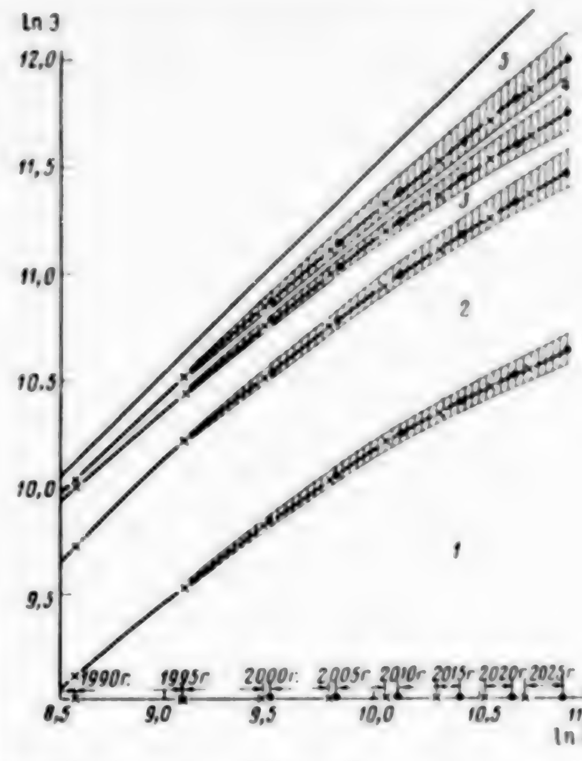


Figure 1. Total Recovery of Energy Resources, in Millions of Tons of Standard Fuel Equivalent, as a Function of Total National Income H, in Billions of Rubles, for Two Alternative Variants.

1. Oil recovery.
2. Gas recovery.
3. Coal mining.
4. Extraction of nuclear fuel.
5. Fuel savings.

*For the variant of a reduction of the average annual pace of growth of national income.
·For the variant of increase in the pace of annual average growth of national income.

In developing these scenarios there was a conviction that they describe basically different strategies for developing energetics. But the presentation in generalized form of the results obtained dispelled this conviction. In order to be sure of this, it was necessary to convert from annual amounts of the production of national income and of all types of energy resources, which characterize the SPEED of development of the economy and of energy, to the amounts of production accumulated during the period, that is, to the indicators of their developmental level. Therefore, in figure 1, change in total national income has been plotted on the horizontal axis on a logarithmic scale, the total production of all types of primary energy resources along the vertical axis, on that same scale.

As is apparent from the figure, the values of the development indicators for both scenarios, which seem so different, lie with remarkable precision on the very same curves which characterize the ties between total national income and total amounts of production of oil and gas (hydrocarbon fuel as a whole), coal (fossil fuel in the aggregate), nuclear energy, and total

production of energy resources. The distinction lies only in the fact that the first scenario (slow development of energy) reaches the same amounts of production and consumption of energy resources as does the second scenario (rapid development thereof), but in increasingly later calendar periods, which are noted in figure 1. Consequently, these scenarios, which are so different in quantitative indicators, actually reflect identical energy strategies which are realized only with a different speed in time.

It is evident from the example cited in figure 1 that the genuine difference in strategies is occasioned by change in the qualitative indicators for energy development: the intensity of energy savings, the energy-resources reserves, and the pace of scientific and technical progress in their recovery and production which is aimed at compensating for the increased expensiveness of fuel as the reserves thereof are depleted, at raising the degree of extraction of energy resources from the ground, and so on. In figure 1, the fine lines in the neighborhood of each broad line show, with a certain arbitraryness, bands of possible changes in the volume of production of energy resources that is accumulated under the influence of the qualitative indicators named. Various combinations of the bounds of these bands also outline the "cone" of possible development of energetics, that is, they form a whole set of boundary strategies.

In order to study boundary strategies, it is necessary to find the main factors (the qualitative indicators) for developing energy systems, to assess the possible bounds of change thereof, and to determine the effective boundary trajectories of energy development that correspond to these limits. Such research cannot be performed for energy as a whole, so it must be divided into parts that correspond to the main aspects for forecasting the development of energetics: the economy and energy consumption; the extraction of natural energy resources; consolidated and partial energy balances; and balances of national-economy resources for developing energetics.

The basic results of the research on boundary strategies for developing energetics are given below for these areas.

3. Determining Factors and Boundary Strategies in the Dynamics of Energy Consumption

For a quantitative study of the main factors that determine the size and structure of energy consumption, an approximate expression was obtained that describes the dynamics of the total and partial energy intensiveness of national income as a function of the economy's growth and structure and the rate of energy savings in various energy-consumption spheres. The logic of the derivation of this expression is as follows.

If the economy is divided into just two sectors--the resource (p) (energy-consuming) and the processing (n), then at each stage in time the national income H is equal to the sum of the net output produced by them

$$H = H_p + H_n = H_0 A, \tag{1}$$

it being the case that

$$H_p = c_p H, \; H_n = (1 - c_p) H, \tag{2}$$

where H_p and H_n are the net outputs (national income) of the resource and processing sectors; H_0 is the national income at the start of the period; A is its index of growth in the period being examined; and c_p is the share of the resources branches in total national income.

Distribution of the overall energy consumption into three parts--the resource Э_p, the generating Э_n, and the municipal-and-household sectors Э_k, which include the whole service sphere, correspond to a division of the national income in terms of two production sectors. Taking this into account, the national income's energy intensiveness can be presented as

$$e=\frac{\text{Э}}{\text{Н}}=\frac{\text{Э}_\text{р}+\text{Э}_\text{п}+\text{Э}_\text{к}}{\text{Н}}. \tag{3}$$

We express the sectors' energy consumption through total energy consumption at the start of the period Э_0, the share therein of each sector $B_p{}^0$, $B_n{}^0$ and $B_k{}^0$, the relative growth of net output H_p/H_{op} and H_n/H_{on} and the relative change of the energy consumption of each of them in time δ_p, δ_n and δ_k

$$\text{Э}_\text{р}=\text{Э}_0\text{в}_\text{р}{}^0\frac{\text{Н}_\text{р}}{\text{Н}_{0\text{р}}}\text{б}_\text{р},\quad \text{Э}_\text{п}=\text{Э}_0\text{в}_\text{п}{}^0\frac{\text{Н}_\text{п}}{\text{Н}_{0\text{п}}}\text{б}_\text{п},\quad \text{Э}_\text{к}=\text{Э}_0\text{в}_\text{к}{}^0\text{б}_\text{к}. \tag{4}$$

Substituting (1), (2) and (4) into (3) produces a formula that determines the dynamics of specific energy consumption of the national income

$$e=e_0\left(\text{в}_\text{р}{}^0\text{б}_\text{р}\frac{c_\text{р}}{c_0}+\text{в}_\text{п}{}^0\text{б}_\text{п}\frac{(1-c_\text{р})}{(1-c_\text{р}{}^0)}+\text{в}_\text{к}{}^0\text{б}_\text{к}\right). \tag{5}$$

If 1985 is assumed to be the initial status, then the share of the sectors in the total energy consumption consists approximately of $B_p{}^0 = 0.6$ and $B_n{}^0 = B_k{}^0 = 0.2$, and the share of the resource sector in the national income produced is $c_p{}^0 = 0.43$. When substituting these values into (5), the dynamics of the energy consumption of the national income is, for primary energy resources

$$e=e_0[1{,}4\text{б}_\text{р}c_\text{р}+0{,}35\text{б}_\text{п}(1-c_\text{р})+0{,}2\text{б}_\text{к}], \tag{6}$$

that is, it is a function of four indicators: the share of the resource sector in the national income produced c_p (which in turn depends greatly upon the index A for growth of national income) and the indicators of the dynamics of energy savings in each of the sectors--δ_p, δ_n and δ_k. An analysis of possible ranges of change of these indicators permitted the analytical expressions for the boundary trajectories (upper and lower) that are cited in table 1 to be obtained as well as the six trajectories of change of the energy intensiveness of the national income in terms of primary energy resources. In figure 2 they are indicated as a function of the relative growth of national income.

Table 2 gives combinations of different variants of structural restructuring, energy saving and rate of growth of national income for the curves depicted in figure 2. As is evident from figure 2a, when national income increases

Table 1

Energy Intensiveness of National Income as a Function of Its Relative Growth A

Variants c_p	Energy consumption where the intensity of energy-savings changes	
	(1) верхние границы $\delta_{рв}=1$; $\delta_{пв}=0,5+0,5/A$; $\delta_{кв}=0,7+0,3/A$	нижние границы $\delta_{рн}=0,5+0,5/A$; $\delta_{пн}=1/A$; $\delta_{кн}=0,5+0,5/A$ (2)
$c_{рв}=0,3+0,13/A$	$e_в=e_0 \cdot (0,7+0,3/A)$	$e=e_0 \cdot (0,3+0,7/A)$
$c_р=0,22+0,21/A$	$e=e_0 \cdot (0,6+0,4/A)$	$e=e_0 \cdot (0,25+0,75/A)$
$c_р=0,13+0,3/A$	$e=e_0 \cdot (0,5+0,5/A)$	$e=e_0 \cdot (0,2+0,8/A)$
$c_{рн}=0,43/A$	$e=e_0 \cdot (0,3+0,7/A)$	$e=e_0 \cdot (0,1+0,9/A)$

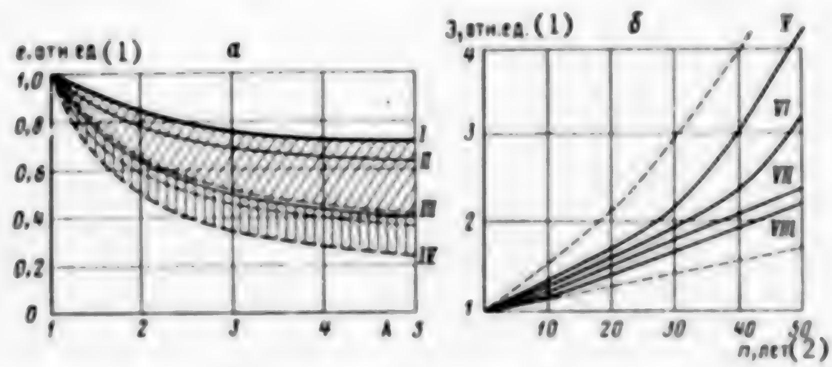
1. Upper limits $\delta_{pB} = 1$; $\delta_{\Pi B} + 0.5 + 0.5/A$; and $\delta_{kB} = 0.7 + 0.3/A$.
2. Lower limits $\delta_{pH} = 0.5 + 0.5/A$; $\delta_{\Pi H} = 1/A$; and $\delta_{kH} = 0.5 + 0.5/A$.

Table 2

Conditions for Developing Energetics

Curve	Rate of growth of national income [%]	Structural restructuring	Energy savings
I	-	Minimal	Minimal
II	-	Maximal	Minimal
III	-	Minimal	Maximal
IV	-	Maximal	Maximal
V	4-5	Maximal	Minimal
VI	3	Maximal	Minimal
VII	3	Maximal	Maximal
VIII	4	Maximal	Maximal

Figure 2. Forecast of Specific Energy Intensiveness and Energy Consumption (the continuous lines are energy consumption, taking into account the correlational tie of the national income's rate of growth and the pace of energy savings; the dotted lines do not take this tie into account).



a. Specific energy intensiveness of national income (for primary energy resources) e as a function of the index of its growth A; and
б. Change of energy consumption Э during the forecast period (see values I-VIII in tables 2 and 3).

1. Relative units.
2. Period, years.

3-fold, its specific energy intensiveness is cut 25-50 percent by the effect of structural factors, given minimum energy savings, and 25-15 percent more when energy savings are intensified. In so doing, it is reduced correspondingly by 25 and 65 percent in the boundary strategies (curves I and IV).

It would seem that, in order to determine boundary strategies for energy consumption, it is sufficient to multiply the extreme trajectories for specific energy intensiveness by the index for growth in national income A. However, the actual "cone" of possible magnitudes of energy consumption is appreciably smaller than is obtained by this formal method because of the correlation between the rate of growth of national income and the rate of savings of energy. Therefore, where the energy savings rate is low, rapid growth of national income is practically impossible, and, where its growth is slow, one should not expect intense energy savings. This correlation can be evaluated only on the basis of average annual rates of growth of national income and of energy savings. The boundary strategies for energy consumption that are obtained by taking it into account correspond to the curves V and VIII in figure 2б. The "cone" of possible magnitudes of energy consumption determined by them is almost one-third less than that obtained without taking the correlation into account (see the dotted lines in the same figure).

Similar results were obtained not only for total energy consumption but also for individual energy bearers. For the most important of them--electricity--the boundary strategies are shown in figure 3.

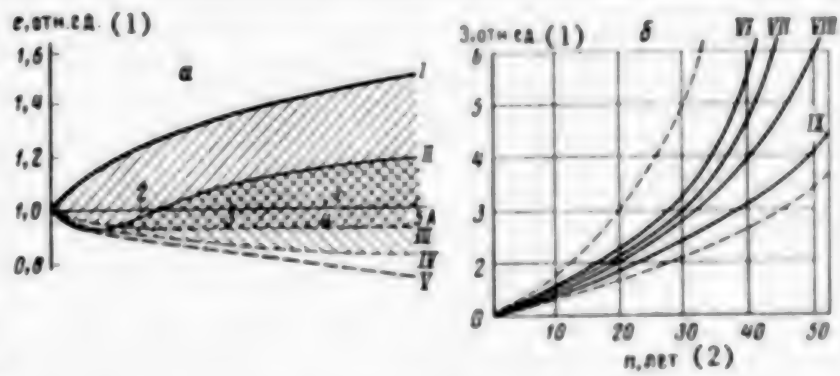


Figure 3. Forecast of Specific Electrical Intensiveness and Electrical Consumption.

a. Specific electrical intensiveness of national income as a function of the index of its growth A.

б. Change of electrical consumption over the period being examined (the thick lines are the electrical consumption curve, taking into account the correlational tie of the national-income growth rate and the energy saving rate; the dotted lines do not take the correlation into account).

1. Relative units. 2. Period, years.

Combinations of different variants of structural restructuring, the degree of intensification of electrification and the rate of growth of national income for the curves depicted in figure 3 are shown in table 3.

It is evident from figure 3 that when the pace of electrification is maximal, the specific electrical intensiveness of the national income grows systematically, but with rapid slowing, having as a limit the growth factor 1.2-1.5. A situation is possible wherein, in the initial period, a rapid restructuring of the economy's structure on behalf of a processing sector that is

Table 3

Conditions for Developing Energetics

Curve	Rate of growth of national income, %	Structural restructuring	Degree of intensification of electrification
I	-	Minimal	Maximal
II	-	Maximal	Maximal
III	-	Minimal	Minimal
VI	4-5	Minimal	Maximal
VII	3	Minimal	Maximal
VII	5	Minimal	Minimal
VIII	4	Minimal	Minimal
IX	4	Minimal	Minimal

mildly electricity-intensive causes a reduction in the specific energy intensiveness of national income, but then an intense spread of electrification outweighs the effect of structural restructuring and leads to growth in specific electrical intensiveness. Where a considerable intensification of electrification fails, a reduction of the specific electrical intensiveness of the national income is inevitable (see figure 3a).

A comparison of figures 2б and 3б indicates that the "cone" of possible trajectories of electrical consumption is much wider than a similar "cone" for overall energy consumption and corresponds to a substantially higher rate of growth in energy consumption.

4. Determining Factors and Boundary Strategies for the Production of Energetics Resources

One can describe the recovery dynamics for fossil fuel--oil and gas for the country as a whole and in terms of the recovery conditions (the shelf, great depths, and so on), and also of coal by main basin--with a precision acceptable for the given study, by a trapezoid which includes: for the fuel-recovery phase--duration T_1, with an annual average growth ($\Delta B_t = B_t - B_{t-1}$), which does not exceed 5-6 percent of the maximum recovery level $\bar{B}$

$$\Delta B_t \leqslant (0{,}05 \div 0{,}06)\bar{B}; \qquad (7)$$

the phase of sustained fuel recovery of maximum duration, which is 1-1.5 percent of the proved geological fuel reserves

$$\bar{B} = (0{,}01 \div 0{,}015) З_п P И, \qquad (8)$$

where $З_п$ are the potential geological reserves of fuel; P is the coefficient of confirmability, that is, of the transfer of potential reserves to explored reserves (as a rule, $0.5 \leq P < 1$); and И is the coefficient of the extraction of explored fuel reserves from the ground; and

the phase of diminishing fuel recovery, in which the value for extraction is reduced from $\bar{B}$ practically down to zero in accordance with an exponential law in such a way that, at each moment in time t, recovery is supported by the remaining proved recoverable reserves for a certain computed period T_p (for oil and gas T_p = 20-40 years, for coal 50-70 years).

In considering what has been said, the length of time that the maximum level of fuel recovery T_2 is maintained is established from the terms of an equation for the whole cumulative recovery of the proved recoverable reserves of fuel

$$3_0 = \frac{B_0+\bar{B}}{2} T_1 + \bar{B}T_2 + \bar{B}T_p = 3_{п}\text{PИ} \qquad (9)$$

The amounts of fuel recovery at each instant in the diminishing recovery phase are found from the fact of an exponential reduction of its value from $\bar{B}$ to B, right down to full depletion of the proved recoverable reserves that remain after completion of the second phase

$$\sum_i \frac{B_{i-1}+B_i}{2} + B_i \frac{T_p}{2} \bar{B}T_p. \qquad (10)$$

Thus, together with the ranges of recovery levels in (7) and (8), possible trapezoidal trajectories for fuel recovery are determined by a combination of the following ambiguous parameters: the calculated period of operation of residual gas reserves T_p; the proved recoverable fuel reserves $3 + 3_{п}$PИ, which combine three ambiguous indicators (potential geological fuel reserves, their confirmability during conversion to explored reserves, and the indicator of scientific and technical progress--the coefficient of fuel recovery from the ground).

Additional analysis has indicated that it is permissible to form boundary strategies for recovering oil and gas only as a function of change of the indicator 3, while for coal, beyond that, as a function of the possible rate of buildup of its recovery by large basin that is in the first phase of development.

The lower limit of the "cone" of possible levels of oil and gas recovery correspond to the contemporary concepts about potential geological reserves, given substantiation of the theoretical coefficient of the confirmability of the unexplored portion of the reserves and given the existing coefficients of extraction. In order to determine the upper limit of the possibilities for recovering these forms of fuel, an extrapolation was made of the dynamics of concepts about the sizes of the forecast geological reserves, which are described by their parabolic dependence upon time, that has prevailed for the last 40 years. Moreover, in determining the upper limit of recovery, it is natural to adopt increased levels of the confirmability coefficient of the unexplored portion of the reserves and of the recovery of fuel from the ground.

Given the prerequisites named, the strategies for low and high recovery of crude differ among themselves by 40 percent in terms of the maximum annual level of recovery and by 30 years for onset of the period of diminishing recovery. In the high strategy, moreover, there is a phase (expressed insignificantly) of growth in recovery with a duration of up to 20 years. In the low strategy a reduction of recovery for 10 years corresponds to it.

For natural gas, the maximal annual recovery under the high strategy is almost 60 percent more than under the low one. Its level can be reached

10 years later and maintained 10 years longer. It is important to emphasize that such assessments of upper strategies for recovering oil and gas correspond to prevailing geological concepts, for example, about the nonbiogenic origin of hydrocarbons (especially methane), and, as a consequence, about the presence of great reserves thereof, particularly at great depths.

In the strategy that corresponds to the upper extraction levels, the average annual increase in coal mining is almost four-fold greater than under the strategy that corresponds to minimal levels. In this case, the highest levels of recovery of Kuznetsk and Kansk-Achinsk coals will be achieved 15 years earlier and will prove to be 20-25 percent higher than under the strategy that corresponds to minimal mining levels.

A study of boundary strategies for developing nuclear power which was made relative to thermal reactors based upon uranium and with consideration of the running time of secondary nuclear fuel also was based upon similar ideas. In this case, the resource restrictions and the physical and technical parameters determine the "upper" strategy for developing nuclear power, while the "lower" strategy is established on the basis of the economic competitiveness of nuclear energy and coal and in accordance with the state of knowledge of the energy balance.

5. The Joining of Boundary Strategies for the Consumption and Production of Energy Resources

The above-listed boundary strategies for producing the basic types of fossil fuel and nuclear power must be brought into correspondence with the boundary strategies for energy consumption--overall and by energy bearer. This is achieved by a balancing of the necessary energy consumption and the potential for producing energy resources--as a whole and for each energy bearer (liquid and process fuel, heat and electricity). In so doing, a consideration of the restrictions on national-economic resources (primarily on capital investment) that the economy is in a position to allocate to the development of energetics is mandatory.

Organization of the task of balancing and optimizing energetics development that has been cited has been realized in an interactive simulation system for long-term forecasting of energetics development. Multivariate studies about this task have indicated the following.

1. Under the boundary strategies for energy consumption that have been obtained and given reasonable export of energy resources, the boundary strategies defined above for recovering fossil fuel and for using nuclear power are in a position to provide an overall balance of energy resources for the whole long-term period examined. The sole necessary condition for this is industrial mastery of the regeneration of spent nuclear fuel and of breeder reactors based upon fast neutrons no later than the end of the 1990's, when the strategies for recovering oil and gas will correspond to low levels, and in the first decade of the 21st Century, when the strategies will correspond to the middle and upper recovery levels. Both of these deadlines are still achievable, although special efforts must be made to realize the first one.

2. An analysis of particular balances--of motor fuel, process fuel, heat and electricity--confirms the conclusion that the development of energetics is relatively balanced overall given the fulfillment of two additional provisos:

the large-scale use of compressed natural gas and mastery in the 21st Century's first decade of the production of synthetic liquid fuel from coal, for a strategy of high motor-fuel consumption, when the recovery of crude will be low or moderate; and

support for an increase in the share of electricity in the overall output of energy resources not below the lower limit. This is dictated by the necessity for inserting into electric-power engineering that breeder-reactor capacity which, even when fuel-cycle operating parameters are medium or low, will enable plutonium to be supplied to steam reactors in a quantity determined by their required participation in the balances for heat and industrial fuel.

3. Restrictions on the permissible amounts of capital investment for the energy activity exerts considerable influence on the strategy for recovering (or producing) energy resources and also, under certain conditions, on the strategy for energy consumption that corresponds to the upper levels of recovery.

It is difficult (even impossible) to obtain in general form analytical expressions that amalgamate boundary strategies for consuming and producing energy resources and which describe combined boundary strategies for developing energy. But these strategies can be found, based on certain rules which limit considerably arbitraryness in determining them, leaving, at the same time, a sufficiently broad field for use of the specialists' experience.

We managed to work out such rules, based on a multivariate study of the prospects for developing energetics, through a simulated interactive system, and to show the prospects graphically in the form of the nomogram in figure 4.

Nomogram-aided formulation of long-term strategies for developing energetics is performed successively by time period. For each period, the work begins with a determination of energy consumption in accordance with the graphics of block I. This is pointed out as an example in figure 4 by the arrows relative to the year 2030.

An informative analysis (particularly with use of the nomogram in figure 4) of boundary strategies for developing energetics, in addition to the well studied problems expected up to the end of the 20th Century, has disclosed that the conditions for developing the USSR's energetics from the end of the first decade to the middle of the second one of the 21st century can be very tense because of the imposition of three unfavorable circumstances: possible rapid reduction in oil recovery; expected stabilization (in accordance with the lower trajectory) of gas recovery; and the attainment of the maximum possible development of traditional nuclear power.

* * *

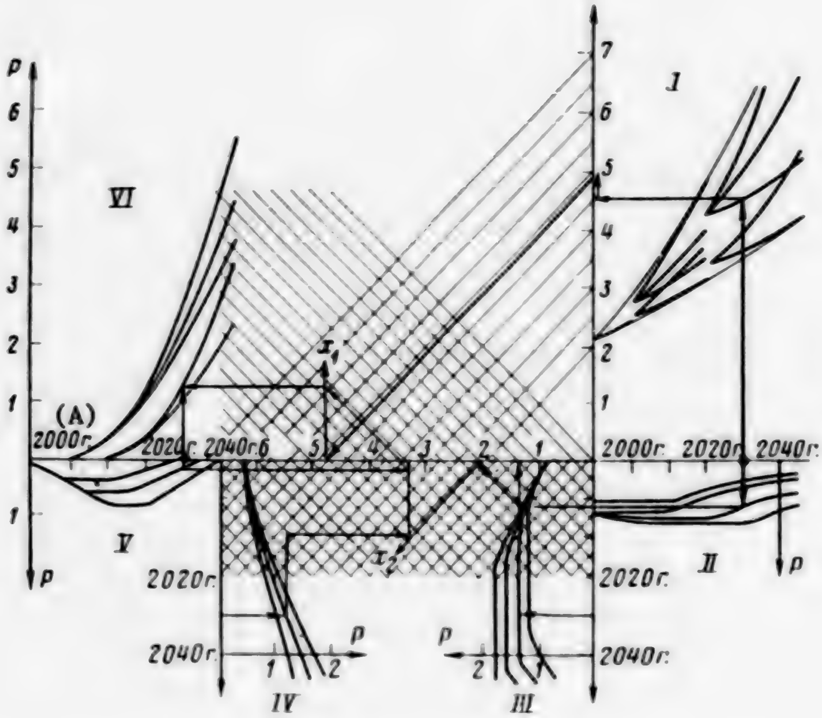
The composition of the main problems of energetics at the start of the 21st Century that were found during study of the boundary strategies, assessment of the quantitative measures for their manifestation and, the main thing, determination of the main routes for solving them will serve as scientific substantiation of the operations for the refinement and supplementation of the USSR Energetics Program for the long term.

Figure 4. Nomogram for Determining the Prospects for Developing Energetics, in Millions of Tons of Standard Fuel Equivalent.

I. Energy consumption.
II. Production of crude.
III. Gas production.
IV. Coal production.
V. Uranium production.
VI. Plutonium production.

x_1 and x_2 are auxiliary construction lines.

A. The year 2000.



FOOTNOTE

*Good examples of the objective trends are the relationships between the national income produced H and the requirement for ultimage energy $\ni$ = 10.5H, and between growth in national income and growth of electrical consumption E = 1.35H, which have been fulfilled with great precision in the USSR since 1955.

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LONG RANGE STRATEGY TO PROVIDE ENERGY FOR USSR

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[Article by A. A. Abramov and A. V. Mukhin (Moscow): "The Formation of a Long-Term Strategy for Providing the USSR's Economy with Fuel and Raw-Materials Resources"; capitalized passages printed in italics]

[Text] A serious obstacle to accelerating the USSR's socio-economic development is the situation that now prevails in the extracting industries complex. It is marked by a steady and progressive worsening of technical and economic indicators for the production of the most basic types of raw materials. New fields must be opened up in remote and uninhabited regions, at great depths, and under complicated mine-geology conditions, and ores are becoming increasingly poorer and require increasingly higher processing costs.

During recent five-year plans, an ever-growing share of productive and other resources, particularly recoverable base minerals, has been going to compensating for the worsening production conditions of the extracting branches themselves and to supporting growth in their output, that is, these branches are increasingly working "on themselves." In order to formulate and implement a complex of measures for overcoming the existing situation, the production and use of raw materials in the national economy must be studied as a unified system, taking into account the characteristics of its various elements, which change with time. The most important aspects of this problem are analyzed below.

Let us dwell first on the role of base minerals and the socio-economic development of the state and certain specific features that affect the nature of its involvement in the reproduction cycle.

Fuel and raw materials, being the initial materials and energetics base for the lengthy processes of producing final output, have complicated ties with the complex of both consuming and servicing branches of the economy. In so doing, the branches that consume fuel and raw materials often are simultaneously also large suppliers for the extracting branches. A substantial and ever-increasing amount of the output of metallurgy, machinebuilding, shipbuilding, automation-resources, and transport and communications goes to geological exploration, the development and operation of fields on land and in water bodies, and the forming of production and nonproduction infrastructures.

The creation of the extracting branches' fixed capital involves extremely large capital investment and long periods for design implementation. Suffice it to say that capital investment for building the six gas pipelines from West Siberia to the European part of the USSR exceeds the costs for the erection of such large industrial facilities as the BAM [Baykal-Amur Mainline], VAZ [Volgograd Automotive Plant], KamAZ [Kama Automotive Plant] and Atommash [Volgodonsk Nuclear-Power Machinebuilding Plant] put together. Average periods for building USSR mining enterprises at present is 7-12 years or more. Thus, in order to produce raw material and fuel, the state must allocate major resources with a greatly delayed benefit from their development.

Raw materials are the initial link in lengthy industrial chains, and the more that an article is processed, the less the influence of the raw materials' cost parameters, which are reflected in prices, on the cost of the final product. According to the authors' computations, the share of expenditures for mining the iron ore needed for smelting 1 ton of pig iron is, in the prime cost of a ton of pig iron, 16-20 percent, and the analogous indicator for 1 ton of steel is estimated at 6-8 percent. According to the data of [1], the share of expenditures for tin in overall production outlays (estimated for 1,000 tin cans) is: tin plate 3.6 percent, tin cans 2.3 percent, finished output (average) 0.5 percent. Consequently, the raw materials that are incorporated into a great multitude of items in which their costs are an insignificant share of the total cost have little effect on the consumer. In accordance with this, the share of output of the raw-materials branches in the gross national product of industrially developed states is not great, and the greater the output that is produced from the raw materials and fuel, the less it is. However, this share does not reflect either the real national-economic effectiveness of using raw materials nor their structure-forming role.

The economic activity involved in extracting and processing raw materials determines greatly the structure of investment in production and employment, the geography and basic proportions of industry, migration of the population, the development of new regions, and the state of the environment. The demand for raw materials affects formation of the state's foreign policy.

Let us examine those elements from which the structure for providing any country with raw materials takes shape. It should be noted right off that this will involve the aggregating of raw materials and fuel in terms of cost, since the overall concept of supply is being discussed here. The cost technique has been selected precisely because of its adaptability to aggregating, since the physical measures for various types of raw materials have a different "weight" (for example, iron ore and diamonds), which can lead to considerable skewing of the picture.

In general form, supplying the country with mineral raw materials consists of

$$D = Q + R + I \quad (1)$$

$$D = m + E, \quad (2)$$

where D is the economy's total demand for raw materials and fuel; m is the national economy's internal demand; E is the demand for fuel and raw-material

commodities for export; Q are the raw materials and fuel produced from the country's raw-materials base; R are the raw materials and fuel produced from waste and put to use; I are the base minerals that come from foreign sources under various circumstances (one-time transactions, long-term deliveries, and compensatory and barter or other agreements).

The use of substitutes plays a major role in fuel and raw-materials provisioning, but this is not reflected in (1), since the replacement of one type of raw material by another is expressed both in the requirement for the corresponding substitute and in its provisioning by various routes. If the substitution is made from renewable resources or thanks to an increase in labor intensiveness or radical change in certain areas of use of a definite type of raw material, then this is manifested in the magnitude of D. Such replacement variants and their role in providing resources will be examined below.

Each term of (1) has different values in time for various countries. For example, the economy's internal demand for fuel and base minerals is marked in some industrially developed countries by a rather sharp jump, which reflects the establishment of a large machinery industry. Then a rising growth in consumption starts that emerges exponentially in various countries for certain types of raw materials. The next stage is a slowing in the increase in consumption, its stabilization, and in some cases even a reduction. Such a nature of change in internal consumption reflects the processes of the development of industrialization, the international division of labor, and the economic structural shifts that have actually occurred in the world [2 and 3]. Right now raw-materials consumption is increasing rapidly in the developing countries. It is natural that various periods, especially the initial jumps, do not coincide in the various countries. Nevertheless, there are certain overall consistencies. Thus, for all the industrially developed countries, the first two or three postwar decades were marked by sharply accelerated growth in the consumption of raw materials and fuel, the end of the 1970's and the start of the 1980's by stabilization and reduction, while for the developing countries an accelerated growth in consumption has been noted since the end of the 1960's and start of the 1970's.

The picture of the production of raw materials and fuel for export by various countries was more diverse. The leading factors here were the natural conditions (the existence of the fields), an interplay of market forces, and change of internal requirements and of transport systems. If the colonial period is excluded, a reduction in raw-material exports in time was typical for an industrially developed country that possessed any substantial raw-materials reserves at all. But certain deviations from this general trend have occurred, for example, an increase in raw-materials exports from England and Norway in the past decade which was associated with conquest of the North Sea oil-bearing basin. Such an increase in these countries is of a "regressive" nature, since it occurred after raw-materials exports had been reduced, unlike Australia, which still builds them up steadily because of the relatively late development of its own mineral wealth. Apart from the fields, the comparative effectiveness of raw-materials exports vis-a-vis other export sectors, which stimulated or weakened the striving to increase raw-materials recovery, influenced the magnitude of raw-materials exports. It is this mainly that can explain the overall trend toward reducing the raw-materials

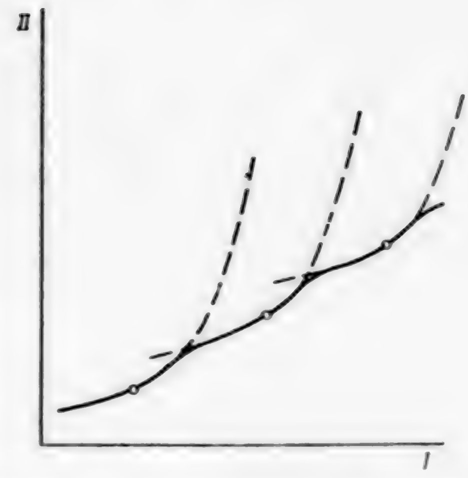
exports of the industrially developed countries, even those that possess large reserves of useful minerals (Canada). The scientific and technical revolution has engendered a number of sectors that are more attractive for investment than the mining sector. At the same time, exports from the developing countries have steadily increased, since raw materials often have been the sole export and, correspondingly, the only way of obtaining foreign exchange. The fact that the small degree of development of the base-minerals base of the developing states enables them to exploit the fields with low production outlays, at a time when fields in similar technical and economic circumstances in the developing countries have been depleted to a great extent, played an important role.

Raw-materials production volume from one's own base-minerals base is determined by the natural possibilities, the technical and economic potential, the degree of maturity of the country's infrastructure, the foreign policy situation, and the place in the international division-of-labor structure. These conditions change in time, and the changes are reflected in production volume. Rich fields with low production outlays are depleted or, on the contrary, new technology enables the economically efficient development of large reserves of useful minerals not previously developed; a lack of the necessary funds and development of the infrastructure does not allow the existing mineral resources to be developed in the desired amount; safety considerations and limitation of the possibilities for imports compel raw materials to be produced in amounts that exceed the economically desirable; a requirement for freely convertible currency also stimulates acceleration in the increase in raw-materials production; and the presence of more attractive targets for investment can constrain it. The overall trend is a gradual reduction in the output of a specific type of raw material after a volume is achieved that is optimal for the country; this corresponds to the potential of its base-minerals base, production technologies and the demand, taking into account the named limitations and stimulating conditions. With the appearance of basically new technologies, a new increase in production is possible.

Raw-materials production is illustrated excellently in the thought of V. I. Lenin that he expressed on the law of "waning soil fertility": "Of course, 'added investment of labor and capital' in comparatively small amounts can (and does) occur even on the basis of a given, unchanged level of technology. In this case also 'the law of waning soil fertility' is applied TO A CERTAIN DEGREE; it is applied in that sense that an unchanged state of technology poses comparatively very narrow limits on additional investment of labor and capital" [LENIN, V. I. Poln. sobr. soch. [Complete Collected Works], Vol 5, p 101]. The example of many countries that have a long history for their extracting industries confirms the correctness of this thought. The dependence between growth in capital investment and raw-materials production effectiveness becomes exponential in nature (figure 1) for many of its forms, and then, upon conversion to a basically new method of production or to a new source, it becomes close to the initial stages of this curve. This also explains why the methods and sources for producing practically all the basic types of raw materials changed radically several times in a 100 or more years [4].

An important component of equation [1] is the production of base minerals and of fuel from waste. Generally speaking, this amount is developed from

Figure 1. Relationship of the Benefit (I) of and Expenditures (II) on the Development of the Fuel and Raw-Materials Base. The dashed lines are exponential-growth curves for unchanged technologies; the circles indicate possible points of balance in the provisioning of raw materials and fuel; and the continuous line is the desirable trajectory for movement of the balance point.



the wastes of mining-industry production and those which arise in the spheres of processing and the consumption of secondary resources. Some of the waste of the first type, which results from the complex composition of base minerals, will be included in the value of Q, that is, it will be viewed as an element in the total volume of the base minerals and fuel that are produced from one's own resources base. Thus, R incorporates industrial and household waste, the utilization of fuel gases, the use of waste heat, and mining-industry waste not included in Q.

The forming of a "raw materials base" of secondary resources occurs throughout the whole chain of extraction and processing of raw materials and fuel, at the stages of the consumption of the resources, and also after its completion. An essential characteristic of processing secondary resources is a sharp reduction in practically all types of production costs in comparison with the technologies for extracting and processing the primary raw materials. This is caused, first, by replacement of the production of the primary raw materials and fuel, which is accompanied right now by an accelerated growth in the consumption of productive resources. Second, the production itself of output from secondary resources requires much lower energy and labor costs because of characteristics of theirs that are higher than the natural qualitative characteristics (content of useful components, degree of purity of accompanying components, and so on). Third, because of relatively small resources consumption, such production pollutes the environment less, and, since the raw materials they use--wastes--is a potential pollutant of the environment, the nature-conservation effect increases still more. For example, according to the U.S.'s Environmental Protection Agency, when producing steel entirely from waste, the consumption of energy is reduced by 74 percent and of potable water by 40 percent, atmospheric pollution is cut 87 percent, and waste from extraction is lessened by 97 percent in comparison with production from primary raw materials.

The requirements for imports of raw materials are occasioned either by the country's lack of them or by higher domestic outlays for production, an ecological situation that will not permit them to be produced, difficulties in transporting (if the territory is large), the creation of strategic reserves, or certain other factors. The forms of the imports and settlements for deliveries are fairly diverse. Right up to the start of the last quarter of the 20th Century, most widely used were: acquisition on the world market or at several large commodity markets, or by retail transactions with various producers, or by long-term contracts for deliveries.

Compensatory trade, which calls for various forms of bilateral and multilateral barter instead of settlements in convertible currency or transfer payments, has been used more widely recently. It takes such forms as barter (an exchange for goods of the same cost), counterpurchases (imports with the proviso that purchases be made of a local commodity for a determined amount), redemption by a share of the output (an agreement to build an enterprise, with compensation for its cost made in future output), compensatory commitments (similar transactions which include, additionally, or in place of technical assistance, direct granting of credits for the construction of mining enterprises), bilateral agreements on economic collaboration which are more general in nature, and trade from the shifting of commodity residues on the clearing accounts of third countries.

Up until recently our country has resolved the problem of raw-materials and fuel supply primarily by a buildup of its own base-minerals base. The increase in production of raw materials and fuel in the USSR in the postwar years surpassed considerably the world average: during 1961-1980 production in the USSR rose 66 percent for coal, while the world average rose 41.3 percent, for oil by 82 and 73.3 percent respectively, for natural gas by 95 and 77.5 percent and for iron ore by 74.5 and 54.5 percent [5]. Overall demand also rose, including demand for the export of raw materials and fuel. The remaining elements of the supplying system were regulated to a great extent.

There were weighty foundations for orienting our economy to our own base-minerals base during the first years of Soviet power: the absence of funds for the imports needed for more rapid industrialization, a hostile encirclement, and, finally, the existence of large reserves. The opening up of large fields of useful minerals and their development promoted an industrialization unprecedented in pace, and the transformation of our country into one of the world's leading industrial powers. Such economic measures as development of the iron-ore resources of Magnitka and the KMA [Kursk Magnetic Anomaly], the oil and gas fields in the Volga region, the Urals and West Siberia, the copper and nickel ores of Norilsk, and the coal resources of the Kuznetsk, Karaganda and Kansk-Achinsk basins, which were viewed as being of paramount importance and which were favored by priority in the distribution of funds.

In 1980 the USSR took first place in the world in the production of base minerals. Right now our country is producing more than 25 percent of the world's output of fuel and raw materials [6], these being obtained from regions a substantial portion of which are poorly developed areas and which experience extreme climatic conditions. Such a load on the base-minerals base cannot help but affect the economic indicators of the mining and extracting industries.

The technical and economic indicators for recovery have deteriorated sharply: capital intensiveness, the capital-output ratio and prime production costs have risen, yield on capital has fallen, and labor productivity has lagged behind the increase in the capital-to-labor ratio [7]. The rate of worsening of these indicators has exceeded considerably those for industry on the average. Right now more than 40 percent of industrial capital investment is being spent on raw-materials and fuel production, and, judging by the plan for 1986, this share will grow (an increase of 31 percent is called for in the oil industry, 17 percent in the coal industry). In so doing, ever

greater expenditures are going not to increased production but to maintenance of recovery levels. Thus, while at the start of the last five-year plan, in the oil industry only 5 percent went to growth, at the end of it all the investment was aimed at maintaining recovery [7], but, unfortunately, even this could not be achieved. Even in those places where an increase in recovery is observed, it is achieved at the price of colossal expenditures.

Scientific and technical progress in the extracting branches, now moving primarily along the path of building up quantitative parameters without a basic change in technology, does not help to improve economic indicators but is an additional cost-raising factor, since the increase in the cost of the equipment is not compensated for by the increase in capacity. Illustrating this also are the relationship in the increase in the cost and the depth of wells in the gas industry, an increase in the prime cost of producing coal because of the use of mining-machinery complexes, and certain other examples [7].

The extracting industries are at an exponential stage of development, where the unchanged state of technology places very narrow limits on added investment of labor and capital, that is, the costs (since they are so great) are not compensated for at all by satisfactory results. There are still definite reserves in the mining and extracting field itself for increasing efficiency in producing raw materials. These are, primarily, the integrated use of the materials which, based upon known technology, can yield an economic benefit during the 12th Five-Year Plan which is roughly assessed by the authors at 12-15 billion rubles. Efficiency in producing raw materials can be raised considerably by a regional combining of natural resources and production facilities and by the creation on that basis of wastefree or low-waste industrial complexes. There are also reserves for reducing losses which reach tens of percent in mining production, including recovery and beneficiation.

The desirability of expenditures for reducing losses should be evaluted by a comparison with the level of growth of the limit costs necessary for producing an equivalent amount of raw materials from new fields. However, an urgent task is that of converting to a qualitatively different level of developing minerals, which requires the creation and development of revolutionary technologies for producing raw materials and the involvement of basically new sources thereof. This can refer to geological-engineering methods of recovery, the development of nonbauxite aluminum-bearing raw materials, new methods for recovering crude oil, the development of technologies for using the World Ocean's resources, automation and robotization of production processes that will allow fields to be operated under extreme natural conditions, and other directions. But for this purpose, time and great outlays are required, the benefit from which will be deferred considerably. Meanwhile, the national economy needs a constant supply of raw materials and fuel. Moreover, ever greater resources are necessary for implementing social programs. Apparently there is nothing to do but to energize other elements that make up the system for providing raw materials.

First one must know how valid is the magnitude of the national economy's requirements for raw materials and fuel. The Soviet Union is the largest producer of oil, steel and a number of other types of raw materials, fuel and materials. The specific intensiveness of our final output in energy and materials is considerably higher than in the developed capitalist countries,

that is, less final output is produced per unit of raw materials. There are several reasons for this. To a great extent, one of them has been engendered for a long time by the gross indicators which have predominated and which stimulated the expenditure of more materials and energy for the production of final output. Another cause is the technical imperfection and low quality of materials used, which compels the weight of many parts to be increased and leads to equipment going out of commission and parts being replaced rapidly. The use of well-known already-mastered scientific and technical achievements will enable metal consumption to be reduced by 10-15 percent and the service life of machines and their more complete operation to be prolonged by 20 percent by bringing the weight of machines and equipment to world standards [8]. Implementation of the whole complex of measures proposed by some researchers opens up prospects for halving the metals intensiveness of social output. The examples of the best production collectives and the successes achieved in developing the technology for manufacturing rolled and drawn articles from nonferrous metals indicate that the output of articles made of, for example, copper can be more than doubled without increasing the mining and processing of ore [9].

Losses of fuel and raw materials during transport are great. By hauling coal in open railroad cars, losses reach 20 million tons per year, and 12-14 percent of the total amount of mineral fertilizer is lost en route just from the plant to the field [10]. Great losses of metal during machining are caused to a considerable extent by the predominance of metal cutting in these processes, and also by the small share of special rolled shapes and blanks in metal output. In some cases more than half of the original metal goes into chips or shavings. Oil and other energy resources are still being used extravagantly. Imperfection of the motor-vehicle fleet leads to great overexpenditure of gasoline and diesel fuel, and the degree of the refinement of crude, which is not severe enough, forces a large amount of light petroleum fractions to be burned in fireboxes. Indeed, just the conversion of the truck and bus fleet to modern diesel engines will enable the saving of more than 20 million tons of crude, which is being expended in increasingly large amounts each year.

In speaking about requirements, it should be noted that large amounts of scarce materials and energy and of labor are still being spent on the manufacture of articles which, like dead weight, take up residence in warehouses and enterprises. Thus, many commodities are not favored by great popular demand, and the number of general-purpose metal-cutting tools exceeds considerably the number of machine-tool operators, and this is true also for tractors. Refraining from the manufacture of some of these commodities or a coordination of their output with the actually existing demand will enable the demand for materials and energy to be revised considerably in the direction of a reduction.

There are also other ways for reducing requirements for the scarcer and more expensive types of raw materials, for example, by replacing them with materials that are more widely distributed or are produced at less cost, energy bearers of mineral origin, and raw materials and energy obtained from renewable sources, and also by radically changing certain ways for them to fulfill their missions. While the first two types of substitution are fairly well known and are described in the literature [1, 10 and 11], the latter requires explanation.

A complex of resources and production processes which perform definite final and intermediate functions exists in the economy and is constantly changing. For example, there are enterprises that mine and produce mineral fertilizers in order to provide agricultural plants with phosphorus, potassium and nitrogen, and there are means for transporting them and applying them to the soil; and a complex of appropriate equipment and a ramified system of telephone cables and wires have been created for telephone communications.

Along with this, there exist or are under development, alternative methods for performing these functions. Thus, in order to preserve and augment the nutrients in the soil, a complex of forest-land reclamation can be applied, organic sources of these substances can be used, and methods for irrigating and for applying fertilizer can be improved. Given a definite correlation of expenditures, this route will be more effective than a further buildup of mineral fertilizer production and will enable the demand for such types of raw materials as apatite, phosphorites, potassium salts and certain other raw materials to be reduced. The introduction of radio telephones will enable the requirement for the copper that is used in telephone cables and wires of traditional telephone networks to be reduced considerably. The transmission of images by facsimile can avoid the material and energy expenditures connected with delivering newspaper matrices to other cities; the development of television reduces the requirement for the construction of new buildings for motion-picture theaters, and so on. Similar measures lend themselves to forecasting and control and can serve to regulate the magnitude of the requirements for base minerals and fuel.

The amount of raw materials needed for export also requires careful analysis, the more so since fuel and raw materials exceed half of our total exports. As is known, export volume is determined largely by the requirements for imports. Judging by fairly numerous publications, a substantial portion of imported equipment remains uninstalled or is used for other than the intended purpose. Careful analysis of the amounts and structure of imported products apparently can lead to the conclusion that a certain reduction in export volume is possible, primarily through the raw-material component, which is increasingly expensive in terms of domestic outlays. Even where it is desirable to conserve or to increase the amounts of raw-materials exports, the magnitude of this component, given the conditions that have been created, should be reduced by an increase in the share of export products with a higher degree of processing.

Thus, there are reserves for reducing total requirements for fuel and raw materials. The implementation of some of them require only improvement in the planning and organizing of production. For realization of the others, expenditures on the development and introduction of resource-saving technologies, improvement of transport facilities, the construction of warehouses, the production of equipment that will replace imported equipment, the creation of competitive export items with a high degree of processing, and so on, are needed. However, measures for saving 1 ton of fuel or raw material right now are one-half to one-third as costly as extracting it [12]. As the experience of industrially developed capitalist countries indicates, where resource saving has been developed especially widely in the past decade, its effectiveness drops as new technologies are introduced that enable the consumption of fuel and raw materials in the more resource-intensive areas to

be reduced. Our economy is, in this regard, at a stage of development during which investment in measures aimed at reducing the requirements will, for a long time more, be substantially more effective than an increase in expenditures on recovery.

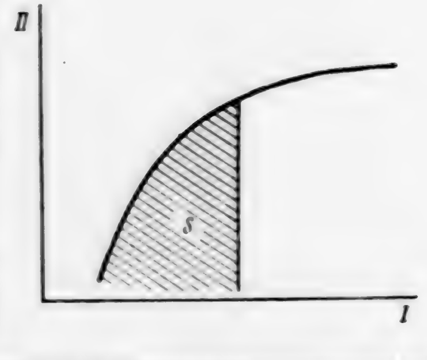
The use of secondary resources and waste entails expenditures. As a rule, these are for the resources spent on gathering, transporting and separating waste. Such measures often require the development and introduction of completely new technologies. From the national economy's standpoint, three basic principles should be adopted in determining the effectiveness of using them.

In the first place, it is more correct to compare expenditures for obtaining raw materials from waste, not with the average costs of extracting them from primary resources but with the limit costs for the given raw material. The latter is usually more than double the average, and so variants that use waste can be extended preference until a rational level of use of secondary resources is attained. The use of waste requires consideration of the benefit from dispensing with the construction and operation of enterprises of the group that brings up the rear, that operates under objectively the worst conditions, since it actually means a reduction in the prescribed volume of extraction of the given resource. The specifics of the actual consistencies in the recovery of useful minerals are such that the greatest changes in amounts of extraction prove to have a very strong effect on the amount of the limit costs. Therefore, a reduction in production volume, even in units of percents, sometimes leads to an extremely great reduction in limit costs and allows avoidance of the construction of new enterprises, often in uninhabited regions, which causes an avalanchelike increase in new construction and associated expenditures. In this case, the ratio of the amounts of use of primary and secondary resources is balanced at the level of equality of the corresponding costs. A reduction as a whole of limit costs for raw materials or of fuel means an extremely considerable savings of the national economy's resources.

Second, the use of waste and secondary resources yields a great ecological benefit, since lands are thereby free of solid wastes and the hydrosphere and atmosphere become purer where liquid and gaseous effluents are put to use. A portion of this benefit lends itself to economic evaluation in the form of increased crop yields, a reduction in the incidence of morbidity, and so on. Another portion, which consists in the conservation and improvement of the landscape's esthetic properties and a saving of unique nature complexes, has social value.

Third, the share of secondary resources actually used in the economy in the overall volume that has been accumulated and that continues to be accumulated is not large at present, so a significant potential benefit is concealed in expanding their use. Relatively small cost increments stimulate in such cases an appreciable increase in the national economy's results from the use of secondary resources (the hatched area in figure 2). The accumulation of indirect benefits in power engineering, transport, the urbanization process, and so on helps here. It is completely natural that when a high level of waste utilization is achieved, further increase in it can become economically less effective and be comparable with an increase in the use of primary resources.

Figure 2. Relationship of Expenditures (I) and the Benefit (II) from Using Secondary Resources.



The USSR is processing ferrous-metal scrap on the largest scale--50 million tons annually. Specific capital investment for obtaining steel from scrap is severalfold lower than from pig iron conversion. The level of the use of scrap still does not exceed one-third of the total annual volume of ferrous-metal waste, the major portion of it going to industrial scrap [10]. According to rough estimates that take the metals inventory accumulated into account, the USSR's development can proceed not only under stabilized conditions but also when the absolute volume of iron ores mined is reduced.

The secondary use of nonferrous metals is extremely effective. Thus, in producing aluminum and its alloys from secondary metal, specific consumption is reduced 20-fold to 25-fold for electricity, and more than 7-fold for standard fuel equivalent, and the capital investment is reduced correspondingly 6-fold to 8-fold [13]. The processing of nonferrous scrap metals in the USSR is, on the average, rather low.

There are great reserves for saving petroleum and petroleum product in expanding the utilization of worn motor-vehicle and tractor tires and of polymer-materials waste and in increasing substantially the scale of collection and processing of spent petroleum product (lubricating oil and so on).

Each year, 200 million m^3 of wastes from beneficiation are formed while extracting asbestos. Processing rock into gravel at enterprises with capacity of 1.4 million m^3 allows reductions in specific capital investment by 2.5 rubles and in operating costs by 0.26 ruble per 1 m^3 of crushed rock, compared with enterprises that work on the raw material of in-house quarries. Out of 48 million m^3 of beneficiation waste, about 40 percent is used in the form of unclassified waste for construction work and for producing asphalt concrete, while building materials are produced from the remaining portion of this waste. Each year the profit from realizing secondary raw materials of the asbestos industry is 12 million rubles, allowing a saving of 110 million kWh of electricity and 20 million tons of raw materials used in producing building materials [14]. Reserves are concealed in the use of secondary energy resources, whose utilization today exceeds 100 million tons of standard fuel equivalent per year. We are talking about hot gases (coke, blast-furnace, converter and oil-refinery gases), as well as exhaust heat (gases, spent steam, hot water, incandescent coke, metal and slag). It is technically possible and desirable to utilize 50-60 percent of this heat; this can save tens of millions of tons of standard fuel equivalent per year. Specific expenditures when using secondary energy resources is 2.5-fold lower than the expenditures needed for an equivalent increase in the production of energy resources. Capital expenditures for the recovery and transporting of 1 ton of standard fuel equivalent in the European part of the USSR is 50-75 rubles, but, with the use of such a volume of secondary energy resources, specific capital investment does not exceed 10-20 rubles (see [15]). As yet, only 12 percent of the national economy's requirements for raw and other materials is satisfied through secondary waste.

This is explained to a great extent by the fact that the existing conditions for economic activity at enterprises does not motivate an expansion of the use of secondary resources and of waste. Improvement of the profit-distributing mechanism, which considers the interests both of the enterprises that process secondary raw materials and waste and the purchases of their output, could play a major role in this regard.

Meeting raw-materials and fuel requirements through imports is, in the long-term context, one of the most stable forms of the international division of labor in the world's economic activity. The USSR, being an active net exporter throughout all its history, has been and remains an importer of a number of raw-material commodities. In solving the problem of the desirability of expanding raw-materials imports, attention should be given to the existing situation of the world market, the conditions for producing raw materials within the country, the effectiveness of other sources, and the nation's foreign-trade potential.

The industrially developed countries continue even now to occupy dominating positions in the world market as producers of output for final consumption and of foodstuffs, without striving, in so doing, to occupy a similar position in regard to raw-materials commodities. In this area, the direct colonial policy is giving way to a neocolonialism, under which these countries, without encroaching on the juridical authority of the sources of natural resources in the developing states, have been able to obtain them under conditions suitable only for themselves. The fact that in the 1960's-1970's the price index for products exported by the West surpasses considerably that for raw-materials commodities, which are the basic items of export by the developing countries, testifies to an unequal economic partnership. Moreover, a substantial portion of the output of the developed capitalist states was sold in the world market as basically new output at monopolistically high prices.

It would seem that the "oil crisis" of 1973 would be the turning point in these relationships. Then the main oil-producing nations, which united in OPEC, employing a large degree of organization and decisiveness in their actions, as well as the extraordinary importance of oil to the world economy, raised oil prices 4-fold over the years.

This success, and also the repeated rises in oil prices that followed it, engendered in the countries that produce raw materials and fuel a number of hopes and myths. A reflection of such hopes, in particular, was the short-term rise in prices also for certain other kinds of raw materials (bauxite and phosphates), reflecting attempts of their producers to follow OPEC's example. And although such attempts did not succeed, the myth was born that the potential of the developing countries that export raw materials will, by collective efforts, influence considerably the world market in the direction of an increase in raw-materials prices that will surpass prices for other groups of commodities and thereby will help to create a more just international economic order.

However, this did not happen, for completely objective reasons, which consisted in the very nature of the prevailing international division of labor and in the role of raw materials in the reproduction process.

The economic decline of world production at the start of the 1980's and the large structural shifts in the world economy that started at the end of the 1970's and has continued up to the present, inflicted a serious blow on the economies of the developing countries. This recession, which coincided in time with an accumulation of a critical mass of resource-saving technologies, the development of which was inspired by the oil crisis, led to a drop in demand and, accordingly, in prices for basic types of raw materials, oil in particular, and to a worsening of the payment balances for the raw-materials producers and to an avalanchelike growth in foreign indebtedness. The world market for fuel and raw materials is today a buyers' market, since the supplies for them exceed demand considerably, with extracting and processing capacity greatly underloaded.

The prerequisities for producing raw materials within a country were examined above. Here we emphasize only that they promote involvement of the foreign soruces that provide them. As for our foreign-trade potential, there are definite restrictions in regard to the purchase of raw materials for freely convertible currency. At the same time, currencyfree forms of trade recently developed open up wide possibilities for obtaining raw materials through deliveries of Soviet commodities and extension of economic, scientific and technical assistance in the construction of enterprises in developing countries that produce raw materials and fuel, that is, with expenditures whose effectiveness can be easily compared with that of other sources of supply.

Let us return anew to equations (1) and (2), which can be viewed as a certain dynamic balance of the national economy's requirements for base minerals and fuel (m + E) and of the sources for satisfying it--for extracting it from the ground Q, and the use of secondary resources R and of imports I. We consider such a multiple-element approach basic, since the "absolutization" of any components does not allow a quick glance at the problem as a whole, taking possible alternatives into account.

Thus, the approach by which the production of base minerals and fuel from our own base-minerals base is viewed as the basic source for satisfying requirements for them now dominates in our economy. For example, the Minister of Nonferrous Metallurgy P. F. Lomako has written: "The main direction for solving the base-minerals problem, it stands to reason, remains successful prospecting, exploration and development of fields" [16]. Such views have been reflected on the whole in a number of works.

It was indicated above that orientation primarily to one's own raw materials signifies the choice of a development path that consumes resources extraordinarily and of exponential trajectories of cost increases, even where there is reduction in the rate of growth in or stabilization of the amounts of recovery of useful minerals.

Neither can the primary use of raw materials from foreign sources be the main alternative for us, since not enough economic potential has been created for sharply expanding international economic exchange in the needed direction. At the same time, the effectiveness of external sources is high for various types of resources, and the corresponding costs under a proper computation are lower than the costs for recovery from our own fields. There are limits to the effective utilization of secondary resources and of measures for saving resources.

The problem that has been posed relates to a number of multiple-criteria poorly structured tasks. It is scarcely desirable to speak here about the possibility of choosing some kind of unified criterion for solving it. The fact is that if maximum satisfaction of the national economy's demand for raw materials and fuel resources is taken as the criterion, then the burgeoning growth of expenditures that ensues would scarcely justify such a choice. Moreover, these criteria can, in their essence, also be independent of each other. Thus, a purely economic striving for a minimization of outlays for covering domestic requirements can be associated with the tendency toward an increase in export shipments both in regard to economic, as well as to social, political and other considerations. In our view, the considerations expressed relative to each component of the dynamic balance can be a basis for developing an overall scheme for the action and mutual coordination of various criteria.

At the same time, since the means, when choosing a development strategy with a unified national-economic purpose, are derived from one source, the necessity for a purely economic approach arises; as does the necessity for the distribution of limited resources in the best possible manner, taking into account the dynamic peculiarities of the system for providing resources. This is occasioned primarily by the basic nature of the mining and extracting branches, their high sluggishness, and their deep tie with the structure of the nation's economics. Such elements as foreign trade possess a dynamic that is capricious, complicated and poorly adaptable to reliable forecasting.

The remaining elements of the systems, although they are more sluggish, are more easily forecast. Finding trends and controlling change of the energy and materials intensiveness of the gross national product or of national income, are completely realistic. There are stable trends of change in the conditions of the deposition of useful minerals, the regional characteristics of the fields, and the quality of the mineral resources being recovered. This enables computation of various expenditures over the long term, using the methods proposed, in [17] for example, and the limit costs for useful minerals. A large number of factors, which frequently are centrifugal or random, and often do not depend upon the domestic economic solutions that have been adopted, complicate very much the task of searching for some kind of promising principles.

The following scheme can be used here, in our view.

A listing of measures, ranked by costs, benefits and time required to obtain them, is made up for each element of the system for providing the economy with base minerals. In so doing, measures for m are ranked by minimum costs for saving a unit of raw materials or fuel, and for Q and R--by maximum output per unit of adjusted costs. The amounts of output saved or obtained, which are correlated with costs, are scheduled in time for each measure. Similarly, a proper list of measures is being developed for E (which are aimed at minimizing its raw-materials component, regardless of increase or decrease of its overall amount), and for I (which are aimed at an economically desirable increase of it). For the two latter elements, time has the least importance, since the amounts of exports and imports can be changed more flexibly and serve to a definite extent as stabilizers while the values of the other elements are changing. In order to provide for stable long-term

import shipments on an exchangefree basis, certain lengthy measures must be a accomplished, such as expansion of the capacity of export output, the construction of enterprises within countries that export raw materials, and so on. However, this does not exclude purchases, if necessary, on the world market, which will be able in a short time to cushion the desynchronization and imbalance in the system for providing raw materials.

Because of the system's peculiarities noted above, and, primarily, its sluggishness, attaining its desired structure involves a definite period (on the order of a five-year plan) and should combine short-term and long-term measures with different times for obtaining the benefit. Without pretending to be exhaustingly complete, let us formulate, in our view, the chief ones among them.

In the area of recovery and processing of natural resources, it is necessary primarily:

to greatly reduce the relative amount of funds aimed at maintaining and increasing the level of recovery, redistributing them to other paths for raising the level of supplying the economy with raw-material resources: a saving of resources, the involvement of secondary raw materials, and so on;

when distributing the funds allocated for the extraction and processing of raw materials, to increase the share aimed at the development and introduction of technologies for integrated processing, which will enable the production of a multiple-sector range of products, based upon one field, to be obtained;

to increase the relative amount of the funds that are released for reduction of losses in the ground and during beneficiation and for the development of basically new technologies; and

to use combinations of local natural resources which often are not of great interest from the branch's point of view but which produce, in the aggregate, an opportunity to organize highly effective production.

In the area of domestic consumption of natural raw materials, one can recommend:

the development of a set of economic and organizational measures that will stimulate reduction of the demand for fuel and raw materials;

a rise in the quality and service life of the materials used;

change in the nature of the consumption of fuel, power and materials to one of saving resources;

the creation of an infrastructure also for providing appropriate technologies aimed at reducing losses at all stages in the production and use of raw materials;

removal from production or a reduction in production of output that is not favored by demand or does not have the prerequisites for use in the amount produced; and

a sharp increase in the share of funds allocated to the collection and processing of secondary resources, primarily for the development and introduction of special technologies in this area.

In the area of the international trade of fuel and raw-materials commodities, one can recommend:

a decrease in export requirements by reducing the importation of products that are not used effectively;

change in the structure of exports in the area of increasing the share of commodities with a high degree of processing; and

conversion to purchase on the world market of various types of raw materials, the extraction of which are too costly at present for our country's circumstances, using, to the extent possible, noncurrency forms of foreign-trade exchange.

The long-range strategy for providing the economy with fuel and raw materials should call for:

the development ahead of time of resources conservation and the use of secondary resources and imports until the costs per unit of fuel and raw materials output saved or produced by these routes approach the maximum (limit) costs for obtaining raw materials;

the development of a mechanism for the centralized redistribution of funds among branches at the highest level of the national economy, based upon the magnitude of the costs and the benefits, the time they are obtained, and the amount of raw materials obtained or saved, in order to achieve a more favorable balance in providing resources;

the transfer, to the extent that the demand, the reduction in effectiveness of resources conservation, and the use of secondary resources will permit, to a new structure for provisioning, in which basically new production technologies for the production, use and transporting of fuel and raw materials resources should play a considerable role; and

the involvement of highly effective fields of nontraditional raw-material resources in operations.

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SYSTEMS ANALYSIS IN ENERGY, APPLICATIONS

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[Article by L. A. Melentyev (Moscow): "Systems Analysis in Energetics and Applications Thereof"; capitalized passages printed in italics]

[Test] The aim of this work is to describe the initial situation, the methodological principles, the basic areas of research, the results achieved and certain problems that face systems analysis in the field of energetics.

The creator of the country's scientific school of energetics, G. M. Krzhizhanovskiy, accurately defined the concept of energetics as one whole--from the sources of the energy resources to the recipients of the energy, inclusive [1], by means of which, we add, energy produced is transmitted directly to the national economy as the customer.

Hereinafter "energetics" (just like its actual synonym, "the energetics activity") is understood to mean precisely this in that broad sense).[1]

Energetics was formed as a unified whole in our country in about the middle of the 20th Century, when a restructuring from actually a "monostructure"--a predominance therein of solid types of fuel--to the broad use of hydrocarbon fuel, occurred in the country's energy balance, the country's electrification began to be developed actively, and the principle of the technical and economic interchangeability of the forms of energy, power plants, energy resources and the means for transmitting them became predominant in energetics.

Another important qualitative change in development of the USSR's energetics was associated with the appearance in the 1950's and 1960's of large energetics systems and then functional systems that were unified for the country--the Unified Electric-Power System, and then the unified systems for gas supply and for oil supply, and, simultaneously, large-scale development of relatively local systems of district heating occurred, and in the 1970's the boosted development of a Unified Nuclear-Power System began.

By virtue of the principle of interchangeability, which is constantly being intensified, it has proved to be practically impossible to find optimal solutions to development of the indicated functional systems outside those actually formulated in the USSR Unified Energetics (overall energetics) System,

the basic elements and ties of which were embraced by the country's Unified Energetics Balance. Taking into account what has been said, the concept and content of the Unified Energetics Balance of the country and its regional hierarchic structure of large power-engineering systems that are being developed are of special significance (not to speak of the technological ties proper) in modern energetics.

In studying the laws and processes for transforming energy, and also the interrelationships of energetics and the economy, energetics science is developing in three chief scientific directions: heat physics; electrification and electrodynamics; and systems analysis of the complex problems of energetics. In so doing, the targets of the latter direction are large energetics systems and their comprehensive "interbranch" problems [2 and 3]. Lying at the basis of the methods of such research, which were created by G. M. Krzhizhanovskiy and his students, is the so-called integrated energetics method of research; its main feature is an examination of individual elements of energetics, not in isolated fashion but in an organic unity with allied elements of the given complex and of energetics as a whole, taking foreign ties with the national economy into account. This method naturally is enriched by the use of such powerful scientific resources as mathematical modeling and computers, which it is logical to call, in modern terminology, the systems methods of analysis.

Energetics systems analyses have an important feature, which is that the object of study comprises both actually existing energetics systems and the models thereof that appear as symbolic systems. In our notion, both approaches are interrelated.

In their development, energetics systems analyses, naturally, use widely the general achievements of the systems approach and systems analysis. At the same time, this scientific direction has its specifics: the research data embraces not only the methods and means for adopting decisions about the control of such systems but also a contensive study of their nature--of the consistencies of development of energetics systems and their general and specific properties. It is on this basis that recommendations are developed for the design of systems for the optimal management thereof, and so on.

At present the theory and methods of energetics systems analysis, just like their application, have advanced so considerably that one can speak positively about their main advantages.

Actually, under this research, each energetics facility is examined in its unity and entirety and its development; any substantiated solutions within the given unity should consider the whole aggregate of direct ties and of feedback. Such an approach helps in a study of this whole and its development and in the discovery of the corresponding causative ties; and it determines the importance of special study of the properties of the system as a whole and its component parts, this being realized where there is incomplete information, a fact that frequently also causes insufficient determinacy of the decisions adopted and requires analysis of the external ties of energetics systems, which to a great extent (also because of the restrictions imposed on the national economy's resources) influences the quantitative phenomena of the principles and properties of the energetics systems. Energetics are examined here as a unity of hierarchically constructed open

systems which respond to actual reality, help to put order into the idea of the vertical and horizontal ties of the energetics activity (including ties with other national-economy complexes), and will permit the essence of the entirety of these systems to be bared qualitatively and often even quantitatively.

The complexity of the objective required wide introduction of such a powerful scientific tool as the computer. This opened up the potential for approximate formalization of a number of the basic relations that were studied in the systems, combined with man's intuition and knowledge, that is, for the application of so-called heuristic methods which provide for new and, frequently, more valid solutions. The use of mathematical models and the computer enables a series of rapid multivariate computations to be executed. And this requires precise regularization of ideas about the system's internal and external ties, which in and of itself undoubtedly is progressive.

At the same time, one cannot help but see the serious dangers in the hypertrophied use of mathematical models. As a matter of fact, mathematical models, especially of the simulation type, are often in essence oriented, imperceptibly for the researcher, to formalized multifactor analysis and thereby disparage the significance precisely of the systems-analysis approach. Therefore, it is important to provide a combination of factor analysis, which often is necessary for the first stage of the research, with a systems study of the object as a unified whole.

In the application of simulation modeling, to a much greater extent than in work with optimization models, the danger arises of obtaining preconceived results and of converting, in essence, to subjective evaluation by experts. Therefore, obviously, it is necessary to seek the best combination of solutions by means of optimization and simulated models.

Frequently, imperfection of the initial information base is underevaluated and, because of that, solutions are arrived at which externally appear to be substantiated. It is necessary to direct the main efforts toward raising the quality of information (where some of the uncertain elements are, for example, prices) and to always understand clearly that the relative precision of the solution cannot be higher than the combined precision of the information used (obviously, it is more realistic to consider the influence of the greatest error of a given type of information on the results obtained.)

Important scientific and practical results have been achieved in the USSR in the area of energetics systems analysis.

The theoretical bases for systems analysis of the nature of large energetics systems and their classification as hierarchical systems have been developed; a hypothesis about the consistencies and trends in the development of these systems has been advanced; study of the properties of energy systems has been promoted, and in this case, especially--the properties of incompleteness of information, inadequate determinacy of optimal solutions, the hierarchical structure, the flexibility and reliability of development and functioning, and so on, were promoted; recommendations for the criterion of optimality--in the absence and in the presence of restrictions on the resources used—were proposed; radical improvement in the methods for adopting formalized decisions were achieved; and so on.

Since similar questions obviously will arise also for some other large man-machine systems, it is appropriate to examine them in more detail. Let us dwell primarily on consistencies in the development of large energetics systems. Academician G. M. Krzhizhanovskiy substantiated in one of his later works [4] a study of the so-called "energetics thresholds." The essence of this study was the fact that at definite stages of their development, the productive forces come into conflict with the energetics base. As a result of the resolution of this conflict, a qualitatively new energetics base appears which promotes uneven growth in the productivity of social labor, which considerably influences development of the material culture of human society as a whole. Examples of such leaps are, in G. M. Krzhizhanovskiy's opinion, the creation of the water wheel, the appearance of steam machinery, conversion to the industrial use of electricity, and creation of the internal combustion engine. Thus, obviously, one may speak about consistencies of the development of equipment for energetics which are manifested objectively in human society. As is known, scientific discoveries appear and are realized when the objective necessity for them arises. Individual personalities and, especially, social formations can accelerate or slow the action of such consistencies but not abolish them. It is natural that what has been said must not be oversimplified; it relates only to the leading elements of the productive forces, including, in our presentation, such elements as energetics.

Based upon the principle that G. M. Krzhizhanovskiy has pointed out, energetics systems analyses have helped to develop study of the principles (at first they were called objective tendencies) in energetics [2]. It should be clarified that such principles are understood today as a specific manifestation of economic laws in energetics (as in the independent self-reimbursing sphere of material production).

A study of the consistencies of energetics has three main contensive aspects. First, both these principles themselves and the strength of their manifestation undoubtedly change in time. But "the future is born in the present," expressing the continuity of development in general and of energetics in particular. Therefore, it becomes necessary, by discovering such consistencies and interrelationships of energetics with the national economy in the past and the present, to study more completely the directions and dynamics of its development, to forecast the future of energetics with greater validity and to control it. Second, energetics systems are created by man, and he establishes the direction of their scientific and technical progress (this relates, particularly, to the socialist community). But such actions of man will be progressive only if they help to realize the principles of developing energetics. Therefore, a knowledge of these principles will increase the effectiveness of man's control actions. Third, an analysis of the principles of scientific and technical progress enables its high-priority directions, toward the realization of which the greatest efforts should be directed, to be singled out.

The importance of studying the principles of development of energetics rises as the value of energy for human society increases. This relates especially to all types of mechanical energy and the electricity used for industrial needs, which directly affect growth in the productivity of social labor and the intensiveness of our economy's development.

Two main groups of such principles for developing the energy field are singled out which, in the author's opinion,[2] are manifested most consistently in the USSR's planned-economy environment: EXTERNAL--which characterize the interrelationships of energetics and the economy, and INTERNAL[3]--which characterize scientific and technical progress in energetics.

The external obviously can include: improvement in the consumption structure in the national economy of ultimate energy in the direction of growth of the share of high-potential energy (mechanical and electrical energy in operating processes) and a corresponding reduction in the share of medium-potential and low-potential energy expended on heating and ventilation and in some operating processes; expansion of the sphere of energy use, which is expressed most consistently in systematic growth in the cost of ultimate energy per capita;[4] and a constant increase in the energy-worker ratio (the furnishing of labor with mechanical and electrical energy that is used in operating processes) as one of the main material prerequisites for productivity growth.

The enumerated principles, as analysis indicates, are, on the whole, firm enough in nature, although the strength of their manifestation in various time periods--the more so in various countries of the world (that is, the industrially developed countries)--can be different.

The internal consistencies of energetics can include: growth of the applicability of the systems approach in energetics, which is manifested more accurately in socialist countries and is characterized by the forming and development of both functional systems and a unified energetics system for the country, and, moreover, for a group of countries; an increase in the utilization effectiveness of energetics resources, which is manifested in systematic increase in the coefficient of useful utilization of the potential energy which is incorporated in them (at which the main efforts in the area of scientific and technical progress in energetics are aimed); and growth in the share of embodied labor with reduction in the share of live labor in the combined costs, which is characteristic for all material production but which has its own specific peculiarities in energetics. Certain authors introduce additionally, as being integral, consistencies in effectiveness in developing energetics; in so doing, effectiveness is understood to mean the ratio of the contribution of energetics in growth of the productivity of social labor and, correspondingly, in the growth of national income to the total combined expenditure of labor on its development. Other authors speak about the principles of developing energetics which are understood as certain universal laws, in the same category as the law of the conservation of energy. Obviously, further comprehensive research is needed in this area.

Experience has indicated that analysis of the quantitative manifestation of the enumerated principles considerably enrich research and the forecasting of energetics development.

Something must be said also about the properties of energetics systems. As is known, the properties of an object determine its difference from other objects or its similarities to them. In so doing, each object (or system) can possess a multitude of properties.

Scientific analysis should enable the main properties to be singled out with a view to making a contensive analysis of them. Larger systems of energetics, as work that has been carried out indicates (see, for example, works [5 and 6]), possess properties which are turned in consolidated fashion into specific properties for a given type of the systems, have been studied as a whole well enough, and are common for the class of man-machine systems but are manifested in a special way in energetics.

The specific properties include: wide interchangeability of energy resources, the means for transporting them, and the various types of energetics installations and energy bearers; a special universality of the output produced and, therefore, an abundance of external ties of energetics systems; the activeness of large energetics systems, which influence considerably development of the economy and the siting of productive forces; a special scale and, therefore, also the structural complexity of systems that are formed as unified groups for a country and even of groups of countries; the material nature of the basic links (electrical lines and pipelines) and, therefore, continuity and, partially, temporal indissolubility of the processes of the production, distribution and consumption of energy; the duality of a number of energetics systems, which consists in the conversion, depending upon the temporal aspect of the study, from production (man-machine systems) to distinctive physical and technical systems (the latter is characteristic from the standpoint of centralized dispatcher-type control for the Unified Electric-Power System, the Unified Gas-Supply System, and so on).

It is important to note that within energetics systems, especially in functional systems unified nationwide, a "multiplicity of states" is marked by great diversity of possible variants for developing the system's structure and elements.

In our presentation, study of the properties of energetics systems must be conducted, as a minimum, from two perspectives.

1. It is known that, for large systems, the problem of providing for a correspondence of the real system with its mathematical model is extraordinarily difficult. It seems that the criterion of adequacy can in this case be the correspondence of the properties of the real system with its model.

2. The properties of the systems that man has created are dual in nature: on the one hand, they were placed there by man in the process of forming the system and, on the other, they appear as objective reality to the researcher of already-formed systems. Therefore, after recognizing the properties of the system and, what is important, the nature of their influence on realization of the principles for developing the system, it is possible, during design and planning, to impart the required properties to the systems or to regulate the strength of their manifestation. The hypothesis can be expressed that timely imparting of the necessary properties to the system will in the near future be a paramount task of the designers.

The final classification of the common characteristics of energetics systems still has not been established. Preliminarily, let us name three groups of them.

1. Structural Properties. Primarily singled out here is the characteristic of centralization of the hierarchical structure of energetics systems, which reflects the actual nature of the main large energetics systems and which has dual importance, determining also the level of centralized distribution in accordance with the material ties of a given type of energy among the set of customers and the level of the system's centralization and organization of control through the corresponding information ties and control organs.

The nature of modern energetics predetermines a high level of centralization, in both the first and the second of its meanings.

2. Properties of Motion. This group includes the properties of flexibility, reliability and adaptation. Recent works indicate the essentiality of the PROPERTY OF FLEXIBILITY of energetics systems; these are understood to mean the capability of the system to change the structure with the rapidity (or speed) necessary in order to provide for normal fulfillment of its functions (development on the required scale and by time period; and functioning during possible disturbances). Imparting great flexibility to energetics systems is an important task of modern energetics.

The PROPERTY OF RELIABILITY is used widely in the energy field in assessing a system's capabilities to perform its function within the limits of the prescribed restrictions. At the same time, some specialists, apparently justifiably view this property more broadly, extending it also to reliability in developing the systems. The latter is understood to mean the possibility for normal development and, therefore, also for functioning of the system when negative disturbances appear--at the stages of design and construction, for example.

The authors are inclined to view the PROPERTY OF ADAPTATION as the system's capability to adapt its motion, including development, to the occurrence of relatively short-term external and internal disturbances (the appearance of new conditions that influence development of the systems).

3. Properties of Controllability

This can be called a complex of properties, with some known degree of arbitraryness. The main property is insufficient determinacy of optimal solutions and the presence of multiple criteria in selecting them.

Both of these properties are important since man, who adopts many control decisions, is oriented toward them. At present, in every case in energetics, the methods for realizing these properties in the process of choosing solutions are controversial. Adoption of optimal solutions at the level of choosing the structure of the systems and their main elements and ties provokes difficulties associated not so much with a substantiated form of expression for adjusted expenditures as with the objective existence of such conditions of the problem as: continuity in the systems-development process and its elements, and the necessity for finding solutions for the system as a whole and for some restricted estimated period of time; incompleteness of the primary information used, an overwhelming portion of which cannot be viewed as being determinate and, at the same time, is not probabilistic, since in most cases it is not related to large-scale constantly repeated information under conditions independent of the observer (in this case,

of officials who adopt the decision).[5] The opinion can be different when converting to the viewpoint of subjective probability, but this provokes many doubts especially for systems optimization tasks. An abundance of computations discloses the high economic stability of energetics systems (in many cases, for energetics systems structures that are very different technically, especially for those being examined, increases in adjusted expenditures prove to be close in dynamics). Such a property of systems objectively creates a zone of economic indeterminacy of the solutions adopted. Its presence inevitably increases the significance of the property of the multiple criteriality of energy systems. However, lacking at present are more or less objective methods for making comparative evaluations quantitatively of incommensurable goals (and of the corresponding criteria). In the author's opinion, in some cases it is desirable to use the well-known "method of concessions." It is especially important at the modern stage of economic development to create a methodology that governs execution of the feasibility computations, taking into account the enumerated features of the system's properties.

Methods of systems analysis for contensive solutions of many fundamental energetics tasks have found wide practical application and have been developed considerably, yielding a fairly large benefit, primarily in the area of forecasting, planning and responsive centralized control. It is sufficient to note that such an important document as the Energetics Program for the Country over the Long Term was created on the basis of large-scale use of multivariate computations, performed on computers, the country's long-term energetics balance and the directions and scale of development of individual functional systems.

Systems methods of analysis, mathematical models, and, based thereon, multivariate energetics computations for compiling five-year plans for the national economy, are finding wide application in the preparation of a number of substantiating papers for the country's supervisory organs. Their use has been considerable also in the long-term planning of energetics systems--electric-power engineering, nuclear power, gas supply, petroleum supply and centralized heat supply (see, for example, works [8 and 9]).

A number of functional energetics systems--the Unified Electric-Power System and the Unified Gas-Supply System, for example--have today reached such a level of complexity that, without the large-scale use of mathematical methods and computers it becomes simply impossible for dispatcher-type central control both of the central system and of individual interconnected systems to provide for normal and post-emergency modes for their operation. At present, mathematical modeling of forecasts and of operating modes of large energetics systems has been transformed actually into a large scientific and technical field.

The use of the systems approach and of mathematical methods in the preplanning selection of standard sizes and of individual parameters for energetics objects, such as electric-power stations, nuclear reactors, petroleum refinersies, and so on, is being expanded. Typical in this regard is the creation of mathematical models of a magnetohydrodynamic generator, which facilitated greatly the choice of optimal parameters for it. Methods for automating the design of various energetics facilities are being developed successfully.

However, formalized methods are still being used relatively poorly in problems of the economic control of systems (ASU's [automated control systems]), which is quite natural: the control of human collectives, just like individual people, is, in the final analysis, always unformalized; it is an especially creative process; and its use of formalized approaches only for individual, and, in the author's opinion, relatively exceptional matters, is progressive.

* * *

An analysis of the basic principles of the work of G. M. Krzhizhanovskiy and his scientific workers, plus a generalization of the accumulated experience of energetics systems analysis, testifies that the constant complication and enrichment of the actual content of energetics requires periodic verification of the appropriateness of both our views and the concepts and methods being applied to the nature of the object being studied and to the prerequisites for its purposeful development.

At a certain stage (confined to the 1960's and the first half of the 1970's), the concentration of efforts on the systems aspect itself of energetics analysis was validated, but at the same time it led to a certain weakening of attention to the economic problems of the energetics complex (which is by no means a synonym for the external ties of economics and energetics) and to such problems as the essence of scientific and technical progress in energetics, the forms of its implementation, and so on. At the same time, a singular "contraction" of the concept of "energetics balance" occurred--it became the main support for the balance of primary energetics resources and inadequate attention was paid to problems of choosing a rational structure for the purposeful use of these resources and of the various types of energy. In particular, solution of the problems of saving energy, which has become acute today, is connected to a great extent precisely with this core cross-section of the energetics balance.

The creation of such important documents as the Energetics Program or the Long-Term Comprehensive Program for Scientific and Technical Progress will require continuous intensification and refinement of our theoretical notions and improvement and generalization of the methodological approach to solving the complicated problems that arise.

Everything that has been said has led to the conclusion that there is an urgent necessity (based upon a generalization of the experience of many years of research performed by the Siberian Energy Institute of the Siberian Department of the USSR Academy of Sciences, the Institute of Power-Engineering Research of the USSR Academy of Sciences, the GKNT [State Committe for Science and Technology] and a number of institutes of branches of the economy) to return once more to the problem of our notions about the object and the subject of the research and to refine and put order into them. This would allow the most important areas and tasks for further work to be formulated precisely and definitely, and approaches to an "outlining" of the areas of realistically conducted research in the form of a unified scientific discipline to be found.

THREE MOST IMPORTANT boundaries in energetics that determine its nature as an object can be singled out for analytical purposes in energetics as a unified whole:

1. The energy field as a national economic complex, which can be viewed as an independent sphere of social production with its inherent peculiarities in the flow of the work process and of augmented reproduction.

The economics of the energetics complex, which emerges as a unified whole, including the proportions of the costs of live and embodied labor, the dynamics of the aggregate expenditures for energetics, labor productivity and yield on capital, the capital and materials intensiveness of energetics, and so on, can be considered the subject of the study.

2. Energetics as an element of the productive forces, that is, as an aggregate of energy installations and of methods for producing and transporting energy which are called upon to provide for transforming the potential energy of the primary energetics resources into ultimate energy and transmitting it to customers. The subject of analysis in this case consists of the energetics balances of the country and its regions (republics and economic regions), and the main attention is paid to problems of the purpose of the use of energy and of energetics resources, taking into account the active influence of saving energy a study of the energetics engineering ties; connected with them; the proportions in the use of various types of energy installations and their parameters; and so on.

Problems of NTP [scientific and technical progress] and the national economic effectiveness of developing the energetics complex, and so on, are being studied at the "juncture" of the two named boundaries of energetics.

3. Energetics as an aggregate of real large and complicated systems. The subject of examination here should be considered to be, for instance, the genesis (that is, the formation and development) of energetics systems, their hierarchical structure at various temporal and regional levels, and so on.

The properties and consistencies of development of energetics; the external ties with interdependent branches of industry, the national economy and the environment; and the methods for controlling energetics at the various temporal and hierarchical levels are being studied at the "juncture" of all three boundaries of the energy field.

A study of energetics from the point of view of the UNITY of the three boundaries described above incorporates development of the theoretical bases, the creation of a methodology for resolving problems of controlling energetics, and development of the most important concepts for developing energetics.

Important and complex tasks on further developing energy-systems research will require a joining of the efforts of specialists of academic and branch organizations, and also of the country's vuzes that are working in this area.

FOOTNOTES

1. The term "fuel and energetics complex" has appeared as an important official concept that embraces the activity of the fuel ministries and the Ministry of Power and Electrification, that is, as a concept which relates to the portion of energetics that is centrally controlled. It does not include such important components of energetics as the decentralized portion of the country's heating activity, a substantial portion of the distribution networks, consumers' energetics activity, and so on.

2. The principles of energetics formulated below should be viewed on the hypothetical level at this stage of the research.

3. The term "internal" undoubtedly is arbitrary, since scientific and technical progress in energetics is created to a great extent in machine-building, metallurgy, chemistry and certain other allied branches of industry.

4. At the same time, a systematic reduction in the national income's energy intensiveness is characteristic for modern energetics, including the results of the energy-saving policy.

5. Work [7] indicated that in energetics, information about the course of natural processes is primarily probabilistic; at the same time, if just one essential element of information in a given problem cannot be considered random, one must not consider the whole problem probabilistic.

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CALCULATING EXPENDITURES, TARIFFS FOR ELECTRICITY

Moscow EKONOMIKA I MATEMATICHESKIYE METODY in Russian Vol 23 No 1, Jan-Feb 87 pp 95-109

[Article by V. A. Volkonskiy and A. I. Kuzovkin (Moscow): "Limit Costs and Optimal Charges for Electricity"]

[Text] 1. The Problem of Determining Limit Costs and Optimal Charges.

An improvement of mechanisms for measuring costs and results, as is known, is of fundamental importance in raising the national economy's effectiveness. At the same time, the planned regulation of prices is one of the most complicated and controversial matters in economic science. The problem of price setting has found a more systematic solution in the theory of optimal planning. However, until now, optimized models and even the basic principles for constructing prices that follow from them are hardly used at all in price-setting practice and in planning and design computations

One of the few exceptions is the fuel and power complex (TEK), where indicators of limit (or, more precisely, incremental maximum) costs for fuel and energy have long been computed and used [1]. In particular, optimal charges for electricity are limit (incremental maximum) costs for it in one time zone or another of the electric-power load schedule. The potential for effective use of optimization methodology when computing prices for TEK output is determined by a relatively small number of homogeneous types of output, their transportability, and the comparative stability of the parameters that characterize production and demand. At the same time, the problem of establishing prices for fuel and energy that meet all reasonable requirements is rather complicated if the problem is to be satisfactorily solved without optimization models.

The same considerations apply also for the narrow task of developing limit costs and charges for electricity. The complexity here lies in the fact that a buildup of electricity requires substantial outlays and not by far is it always economically desirable. Therefore, change in the requirements for energy as to time of day, day of the week, and season of the year necessitates the use of different types of electric-power stations in order to cover the requirements of the various time zones. Thus, although electricity is physically a homogeneous product, in the economic sense it forms different types of output, being generated at different periods of time. Its

multiplicity makes the task of determining a rational system of charges for electricity difficult, or even impossible, without optimization models.

It is now generally acknowledged that prices should correspond to the plan for the production and distribution of a product. This means that computations of the effectiveness of economic measures that rest on them must reflect national economic interests. In particular, the price of 1 ton of standard fuel equivalent of any energy bearer should cover the specific adjusted costs of measures for saving it, if these costs do not exceed the specific adjusted costs for expanding its production. It follows from this that prices must be established at the level of incremental maximum costs.

Existing prices for fuel and charges for electricity are considerably lower than the level of incremental maximum expenditures. Therefore, in planning and design computations for the fuel and energy complex, the values of the limit costs are used instead of the existing prices. Stating existing prices below the economically justified level exerts a negative influence on the result of the policy on saving fuel and power resources and often leads to a contradiction of the cost-accounting interests of their producers and consumers with the interests of the national economy, to an artificial overstating of requirements for these resources, and to a violation of cost-accounting relationships in the TEK.

However, the indicated duality in evaluating the energy bearers still occurs, and it must be considered in determining both the limit costs for electricity and the charges which are intended for current financial computations, since the costs of producing electricity are set on the basis of an assessment of the fuel used to generate it. The first should be based upon the limit costs for the fuel, the second on existing prices. In this case, naturally, evaluations for electricity are obtained that vary considerably both in overall level and in structure.

The urgency in differentiating limit costs and charges for electricity as a function of the time of its consumption obviously is proved, first, by the sharp differences (severalfold) of the corresponding socially necessary expenditures (see below) and, second, by the actual situation that prevails in some interconnected energy systems (OES's). This situation is marked by an often severe shortage of electricity during peak hours and, simultaneouslay, surpluses of power during nighttime hours. Thus, the saving of energy, which is acquiring increasingly great importance in the modern economic situation, consists to a great extent in the optimal redistribution of its consumption among the time zones.

The question about the effect of differentiated charges, based upon the behavior of power consumers during current economic activity, has not been studied. Obviously, their activity depends to a decisive degree upon the comparative strength of the cost-accounting stimuli and the planning and administrative restrictions within their economic-incentive system. The recently introduced system of encouraging enterprises to save fuel and fuel resources through material-incentive funds can help to intensify their activity. But possibly even this will not yield a great benefit since, as has been noted repeatedly, the existing economic mechanism poorly motivates enterprises toward reducing costs, the more so because the objective technological possibilities, the cost-accounting interests, and the requirements

of the plan often fairly rigidly restrict the flexibility of energy consumers in terms of time. The planned standards (ceilings) on material expenditures (including expenditures of energy) that have been introduced, with sanctions for violating them, should persuade enterprises to reduce overall power consumption. Unfortunately, these ceilings were established in kind. In this form they not only cannot stimulate, but, on the contrary, can slow the introduction of measures for reducing national economic expenditures by redistributing power consumption in time. Thus, the conversion of customers from a day zone on the load curve to a night zone usually is accompanied by a certain rise in overall power consumption, and it therefore proves to be unacceptable to them. In order that a charge differentiated in time may prove to be an active tool in optimizing electrical consumption, the terms for limiting electrical consumption, for example, to convert to a restriction in terms of a cost indicator, also must be changed. One can speak more definitely about substantial possibilities for influencing the differentiation of limit costs on decisions adopted during design and plan computations for the long term.

The necessity for differentiated charges for electricity by time of day, day of the week and season of the year on the basis of the theory of optimal planning was noted by L. V. Kantorovich in 1966 [2] and was emphasized again in [3]. According to his assessment, the introduction of such a system will enable electrical generation in the country to be increased by 5-10 percent. Work [4] cites a model with continuous time for finding zones in each of which the requirement for electricity is covered by a definite type of electric-power station, and also for finding values for optimal charges in these zones. This model is fairly simple and is suitable for practical use, but it is based upon some presuppositions, a consideration of which can be essential, especially in average-period computations. Thus, it examines only the types of electric-power stations newly erected during the plan period. Moreover, it is proposed that the capacity for all types of power stations be built up during the plan period. Section 2 cites a modification of the indicated model that makes up for these deficiencies.

In addition to what has been noted, this model does not consider the permissible sets of parameters for operating electric-power stations or the times for starts and stops, and it proposes that all types of electric-power stations be capable of picking up or reducing a load intantaneously. The solutions obtained proved to be approximately correct because the stations' flexibility is reduced as capital intensiveness increases, while capital-intensive stations, according to the models, cover longer time zones of the electricity-requirements schedule and requires a smaller number of disconnections. In order to consider the indicated factors more completely, section 3 examines a model of linear programing which proposes that the allocations of time zones be prescribed previously (it is determined by the schedule of the requirement for energy). For purposes of long-term planning, the simplest variant of this model, which is described in [5], can be used, in which the values for optimal charge are presented in the form of simple analytical functions of the adjusted-cost components. These functions are necessary for a qualitative economics analysis, particularly for finding the sensitivity of the charges to change in evaluation of the various types of fuel.

In our opinion, such models can also be a useful addition to more complicated and labor-intensive models for optimizing the development and operation of

power systems that are being studied in a number of scientific centers, particularly in the Siberian Power-Engineering Institute of SO AN SSSR [Siberian Department of the USSR Academy of Sciences] [6 and 7].

This work examines just one typical situation: three time zones, two days of the week (a workday and a nonwork day), two seasons and four basic types of steam power plants, but the proposed methods and models can be used for analysis and computations for other circumstances.

The total annual number of hours of operation can be divided into time zones by different methods. Within the days, the following hours are usually singled out: 1) the peak load; 2) the daily offpeak loads; and 3) the nightly reduction in the load. Histograms of the actual average consumption of electricity for each hour of the day are the basis (figure 1). Along with electrical-consumption schedules in ordinary calendar time, consumption schedules in which time segments are shown in a procedure for reducing the load--the so-called load curve in terms of duration (D(t) in figures 2 and 3)--have long been used for planning and research purposes in power engineering. In approximating this schedule in a three-stage manner (figure 2), we received for each of the three time zones the value M_j--the total capacity of electric-power stations of all types, which is necessary for satisfying the requirement for each hour of the time zone j (determined for the hour with the maximum load) for j = 1, 2 and 3.

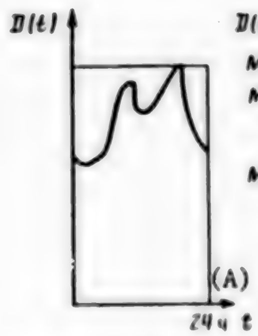


Figure 1. Daily Load Schedule.

A. 24 hours.

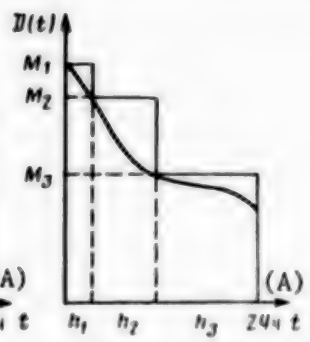


Figure 2. Daily Load Schedule in Terms of Duration.

A. 24 hours.

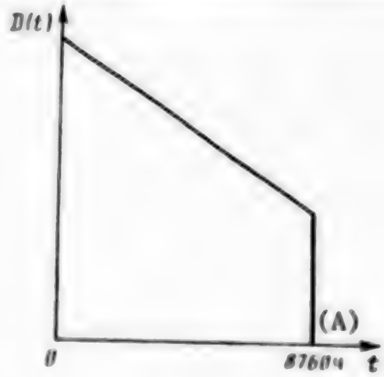


Figure 3. Annual Trapezoidal Load Schedule in Terms of Duration.

A. 8,760 hours

Each zone j is described by the duration indicator h_j. For each zone of the daytime load schedule, the type of electric-power stations turns out to be limiting. In the normal situation, gas-turbine installations (GTU's) are usual for the peak zone (j = 1), semipeak (flexible) condensing electric-power stations (KES's) for the daytime zone (j = 2), and base-type electric-power stations--base KES's or nuclear-power stations (AES's)--for the nighttime zone (j = 3). Charge schedules are established for the electricity for each zone. The number of charge schedules increases where differences in the circumstances for electricity consumption on work days and nonwork days and during the winter and summer seasons are considered. A 12-charge schedule (see section 4) can be computed to take these factors into account.

Questions of improving the existing methodology for determining limit costs for electricity, based upon the approach proposed in this work, are examined in section 5.

A two-charge schedule for industrial customers which is divided only into peak and offpeak zones of the day does not promote transferral of the load to the nighttime zone, since the payment per 1 kWh in the daytime and nighttime zones are one and the same, yet the cost of producing power for the night zone is substantially lower than for the daytime zone.

An economic experiment on the introduction of charges for electricity for industrial customers, differentiated by three zones of the day (peak power, daytime and nighttime), has been under way at Lenenergo [Leningrad Regional Administration for Power-Systems Management] since 1 July 1984 and at four other of the country's power systems since 1 January 1986. The All-Union Interbranch Conference on expansion of the indicated economic experiment, the decisions of which approved the approach to determining optimal charges and limit costs for electricity, met in Leningrad in October 1985. Studies on questions of differentiating rates for electricity are being conducted in many countries (see the surveys in [8 and 9]).

In most works, differentiated rates are computed on the bases of the maximum production outlays (limit costs). However, practically realizable optimization models for determining the place and duration of optimal time zones for charge rates are not being put forward for the general case.

2. Model for Determining the Duration of Time Zones and Charges for an Optimal Graduated Schedule.

Let us examine the problem A of the expansion and use of power-engineering capacity for satisfying a given requirement for electricity with the lowest aggregate expenditures.

$$\sum_{i=1}^{I} \Pi_i x_i + \sum_{i=1}^{I} q_i \int_0^T y_i\,dt + \sum_{j=1}^{J} \bar{q}_j \int_0^T \bar{y}_j\,dt \to \min, \qquad (1)$$

$$\sum_i y_i(t) + \sum_j \bar{y}_j(t) \geq D(t), \qquad (1')$$

$$0 \leq y_i(t) \leq x_i, \quad i=1,\dots,I, \qquad (1'')$$

$$0 \leq \bar{y}_j(t) \leq \bar{X}_j, \quad j=1,\dots,J, \quad t \in [0,T], \qquad (1''')$$

where $i = 1, \dots, I$ is the number of types of newly built electric-power stations, and $j = 1, \dots, J$ is the number of types existing at the start of the plan period. Sought are the capacities x_i, $x_i \geq 0$, of the newly constructed electric-power stations and the amounts of energy generated $y_i(t)$ and $\bar{y}_j(t)$ per unit of time for these and other stations. The capacities $\bar{X}_j$ of the existing stations are given. Each type of power station is characterized by varying costs (expenditures for fuel, taking into account consumption for the power station's in-house needs and losses in the grids) for the production of a unit of energy q_i and $\bar{q}_j$ (it is proposed that they be constant in time); [0, T] is the period of time (year or days); Π_i are the

constant costs connected with electric-power stations of i unit capacity during the period [0, T]: $\Pi_i = (E + a_i)K_i^{э} + (E + a_л)K_л$, where E is the standard capital-investment effectiveness; $k_i^{э}$ is the specific capital investment per increase of 1 kW of capacity of a type i electric-power station; a_i is the norm for constant costs per unit of capacity of an electric-power station of type i (amortization, wages and so on, including expenditures for creating reserve capacity and for the station's in-house needs): $K_л$ and $a_л$--the capital investment and the norm for constant annual expenditures for the transmission of 1 kW of power--were taken to be identical for all types of electric-power stations; and D(t) is the given requirement for energy per unit of time.

A dual evaluation p(t) of the restriction (1') is interpreted as the charge payment for the use of a unit of electricity at the moment of time t; and the evaluations $r_i(t)$ and $r_j(t)$ are limited by (1'') and (1''') as rental-equivalent evaluations of the corresponding productive capacity per unit of time. Since none of the relationships in the problem is violated during change of the order (transposition) of the moments of time, then the optimal values of the unknown functions $y_i(t)$, $\bar{y}_j(t)$ and p(t) at the point t depend only upon the value at this point of the sole characteristic among the original data--function D(t)--that change in time. Therefore, without the limitation of generality, we propose that D(t) is not an ascending function (see figure 2). In other words, the schedule for duration of the load possibly can be used directly as D(t). It is easy to prove that the solution of the problem (1)-(1''') coincides with the saddle point of the corresponding Lagrangian function. An analysis of the saddle point leads to the following relationships of supplementing flexibility

$$\int_0^T (p^* - q_i^* - r_i^*) y_i^* \, dt = 0, \quad \int_0^T r_i^* (x_i^* - y_i^*) \, dt = 0, \quad i = 1, \ldots, I, \tag{2}$$

$$\int_0^T (\bar{p}^* - \bar{q}_j - \bar{r}_j^*) \bar{y}_j^* \, dt = 0, \quad \int_0^T \bar{r}_j^* (\bar{X}_j - y_j^*) \, dt = 0, \quad j = 1, \ldots, J, \tag{2'}$$

$$\left(\Pi_i - \int_0^T r_i^* \, dt \right) x_i^* = 0, \quad i = 1, \ldots, I, \tag{2''}$$

where the asterisk in the index is the optimal value of the corresponding function.

These relationships follow directly from (2) and (2')

$$\int_0^T (p^* - q_i) y_i^* \, dt = x_i^* \int_0^T r_i^* \, dt, \quad \int_0^T (p^* - \bar{q}_j) \bar{y}_j^* \, dt = \bar{X}_j \int_0^T \bar{r}_j^* \, dt \tag{2'''}$$

and from (2'') and (2''')

$$\int_0^T p^* y_i^* \, dt = \Pi_i + \int_0^T q_i y_i^* \, dt, \qquad (2'''')$$

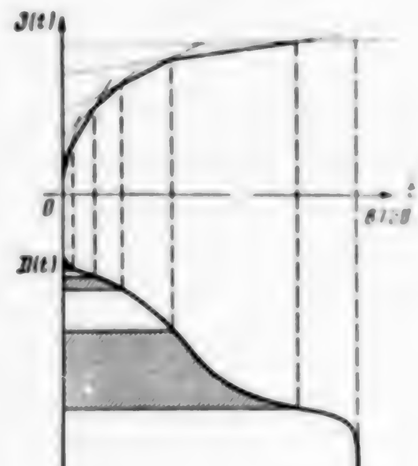
which are easily interpreted as the financial equations of the expenditures and the results: (2''')--the profit of the stations of each type, is equal to the rental-equivalent evaluation of production capacity; (2'''')--the proceeds for the charge, are equal to the adjusted expenditures for the creation and functioning of the given type of stations.

Work [4] examines a simplified variant of problem A, where the existing stations are absent: $\bar{X}_j = 0$, $j = 1, \ldots, J$. In this case the optimal charge p^* can be constructed in the following form. Let us denote by

$$\text{З}_i(t) = \begin{cases} 0, & t = 0, \\ \Pi_i + q_i t, & t > 0, \end{cases}$$

the adjusted expenditures for the creation and functioning of individual capacity i over the time t and, by $\text{З}(t) = \min_i \text{З}_i(t)$, the minimal adjusted expenditures (see figure 4). If $\text{З}_k(t)$ does not take part in forming the broken line $\text{З}(t)$, $\text{З}_k > \text{З}$ for $0 < t < T$, then the corresponding type of stations is not used in the optimal plan. Further, it is proposed that all types of stations be included in the optimal plan and be renumbered in descending order q_i, $q_1 > q_2 > \ldots$ and in ascending order Π_i, $(\Pi_1 < \Pi_2 < \ldots)$.

Figure 4. Graph of the Broken Line $\text{З}(t)$ and Graph of the Duration of the Load D(t).



It can be verified that the derivative function $\text{З}(t)$: $p^*(t) = \text{З}'(t)$, $t \in [0, T]$ being understood as a generalizing function, since $\text{З}(t)$ has a gap at the point $t = 0$, can be taken as the optimal charge.

In other words, $p^*(t) = \bar{p}(t) + \Pi_1 \delta(t)$, where $\bar{p}(t)$ is a piecewise constant (graduated) function, its zone of constancy coinciding with the closed intervals

$$\Gamma_k = (t_{k-1}, t_k] = \{t : \text{З}(t) = \text{З}_k(t),\ t > 0\},$$
$$\bar{p}(t) = q_k \quad \text{для } t \in \Gamma_k, \quad k = 1, \ldots, I,$$

where $\delta(t)$ is Dirac's δ-function, that is, a generalizing function which possesses the characteristic $\int_0^T \delta(t)\varphi(t)\,dt = \varphi(0)$ for any continuous $\phi(t)$, and Π_1

are the constant costs for creating and operating 1 kW of capacity of peak electric-power stations.

Thus, the charge $p^*(t)$ can be establisned for each time zone, except for the peak zone, at the level of the fuel component of the costs that are limiting for its type of electric-power station. The charge in the form of the δ-function obviously cannot be realized in the form of payment for the amount of switchboard power, since the duration of its effect is zero. However, it can be introduced in the form of a payment (let us signify it by α) for the power of the energy-consumers' power units that are linked to the power grid (the value of α is measured in rubles/kW). Industrial customers now use this form for paying for energy during peak-load hours. It is called payment for participation in the load maximum. In the peak zone, a two-charge schedule (α, q_1) is used with payment of $\alpha = \Pi_1$ for the power consumed, and the additional payment of q_1 per 1 kW consumed is equal to the specific fuel costs for peak electric-power stations.

Work [1] does not call for payment for participation in the maximum of the load. Limit costs for electricity are established only per estimated unit of electricity consumed. Under such a proposal, an increased charge p per 1 kW should be established for the peak zone, which will cover both current costs and capital costs for generating the peak station's power. Therefore, the amount of the charge p should be determined from the proviso of equality of payment for the electricity produced by all the electric-power stations in the peak zone in accordance with the charge p and the two-charge schedule Π_1 and q_1

$$p\left[\int_0^{t_1} y_1(t)\,dt + \left(\sum_{i=2}^{I} x_i\right)t_1\right] = \Pi_1 \sum_{i=1}^{I} x_i + q_1\left[\int_0^{t_1} y_1(t)\,dt + \left(\sum_{i=2}^{I} x_i\right)t_1\right].$$

It is proposed that in the peak zone all electric-power stations, except peak-power stations, operate at full capacity during the scheduled duration of this zone t_1. If it is assumed that

$$\int_0^{t_1} y_1(t)\,dt + t_1 \sum_{i=2}^{I} x_i = \beta t_1 \sum_{i=2}^{I} x_i,$$

then $p = \Pi_1/\beta t_1 + q_1$. In practice, $\beta = 0.95$–0.97. Consequently p differs little from the value $\Pi_1/t_1 + q_1$.

The matter becomes complicated when converting to the general problem A. Let us examine the case of the presence of a single type of capacity ($J = 1$) of size $\bar{X}$ at the plan period start. We construct first a function for minimal costs $\text{З}(t)$ just for newly constructed stations and $\bar{\text{З}}(t, R)$ for existing capacity

$$\bar{\text{З}}(t, R) = \begin{cases} 0, & t = 0 \\ R + \bar{q}_1 t, & t > 0 \end{cases}, \tag{3}$$

(as a function of the unknown parameter R). For each value of $R \geq 0$, a time zone for operation of existing capacity $\bar{\Gamma}_1 = [\bar{t}_0, \bar{t}_1] = \{t: \bar{З}(t, R) \leq З(t)\}$ is determined, and the corresponding amount of required capacity is $\bar{x}(R) = D(\bar{t}_0) - \bar{D}(t_1)$. If t_0 or t_1 coincides with the points of discontinuity of the the function D(t), then we assume $\bar{x}(t_1) = \overline{\lim}_{s \to t_0} D(s) = \underline{\lim}_{s \to t_1} D(s)$.

It can be stated: 1) $\bar{x}(0) \leq \bar{X}$ and 2) $\bar{x}(0) > \bar{X}$. Let us define R*. For the first case, R* = 0, for the second R* is the root of the equation $\bar{x}(R) = \bar{X}$ (or such a value of R at which $\bar{x}(R) > \bar{X}$, $\bar{x}(R - 0) \leq \bar{X}$).

As is easy to verify, R* is the rental-equivalent evaluation of the capacity existing at the start of the plan period: $R^* = \int_0^T \bar{r}_t^* \, dt$. In this case, $З^1(t) = \min [З(t), \bar{З}(t, R^*)]$ is a function of minimal costs for the whole task, and its generalized derivative p*(t) is the optimal charge. Usually the function D(t) is given approximately as piecewise linear. Then $\bar{x}(R)$ is also piecewise linear and be easily constructed.

Let us note that where $\bar{x}(0) < \bar{X}$, not all the existing capacity $\bar{X}$ is used in the optimal plan at the end of the plan period. A part of it, namely $\bar{X} - \bar{x}(0)$, should be transferred into the reserve or dismantled as obsolete. In this case R* = 0.

In the general case (J > 1) the optimal charge is also a generalized variable of the function of minimal costs

$$З^J(t) = \min [З(t), \bar{З}_j(t, R_j^*), j = 1, \ldots, J], \tag{4}$$

where

$$\bar{З}_j(t, R_j^*) = \begin{cases} 0, & t = 0, \\ R_j^* + \bar{q}_j t, & t > 0. \end{cases}$$

Defining the rental-equivalent evaluation R^*_j becomes complicated. The method described for the case J = 1 is suitable for the more general situation with any number J of types of existing electric-power stations, where the zones $\bar{\Gamma}_j$, which corresponds to the existing stations

$$\bar{\Gamma}_j = \{t : \bar{З}_j(t, R_j^*) \leq З^J(t)\},$$

are divided by zones for newly built stations. This condition is met in a particular case of practical importance, where stations of the same type as the existing ones are created, only, possibly, with somewhat lower parameters of the variable expenditures $q_j < \bar{q}_j$,* which form the series

$$\bar{q}_1 > q_1 > \bar{q}_2 > q_2 > \ldots, \tag{5}$$

the capacity of the existing stations being fairly small, and new stations of all types are built during the plan period.

Let us note that the optimal plan for the situation that satisfies the condition (5) is characterized by the following property of practical importance: the existing capacity of all types, except perhaps for peak capacity (j = 1), are used more completely as a rule. More precisely, the existing capacity of the type l > 1 (or a part of it) can prove to be excessive only in the case where existing capacity with the numbers which precede j < l are not

being operated and new ones are not being created. Actually if type l capacity is not used completely, then its rental-equivalent evaluation R_l* is equal to zero and, by virtue of (4), $З_j(t)$ and $\bar{З}_j(t, R_j^*)$ for $j < l$ exceed $\bar{З}_l(t, R_l^*)$ and, consequently, also $З(t)$ for all t. Therefore, the zone where stations with the numbers $j < l$ would be limiting are absent.

If the conditions of [5] are met, that is, new power stations of all types (peak, semipeak and base) are introduced and all existing ones are operating, then construction of the broken line for minimal expenditures $З(t)$ is reduced to solving the system of equations obtained from the equality of the adjusted costs per 1 kW of the power of the electric-power stations of the corresponding type that are situated alongside on the annual load schedule D(t) and function an identical number of hours per year

$$\begin{gathered} \Pi_{j-1}+q_{j-1}t_{j-1}=R_j^*+\bar{q}_j t_{j-1}, \\ R_j^*+\bar{q}_j\bar{t}_j=\Pi_j+q_j t_j, \\ D(t_{j-1})-D(\bar{t}_j)=\bar{X}_j, \quad j=2, 3. \end{gathered} \tag{6}$$

For peak capacity ($j = 1$), either the second and third equations of system (6) are solved for $j = 1$, and the unknowns R_1^* and $\bar{t}_1$ are found, when $x_1(0) > \bar{X}_1$, or $R^* = 0$ and t_1 is determined from the equation $\bar{q}_1 t_1 = \Pi_1 + q_1 t_1$, when $x_1(0) \leq \bar{X}_1$.

If existing stations are not considered, then the optimal duration of operation t_j of the new stations is found from the system (6) of the form

$$\Pi_{j-1}+q_{j-1}t_{j-1}=\Pi_j+q_j t_{j-1}, \quad j=2, 3.$$

In the general case, when considering the existing stations, the value t_j will be less. Taking R_j^*, $j = 2$ and 3, from the first equation of system (6) and substituting it into the second, we get

$$t_{j-1}=\frac{\Pi_j-\Pi_{j-1}}{q_{j-1}-q_j}-\frac{(\bar{q}_j-q_j)(\bar{t}_j-t_{j-1})}{q_{j-1}-q_j}.$$

In finding the optimal duration of operation for all types of power stations t_j and $\bar{t}_j$ and knowing the annual load schedule in terms of the duration D(t), we determine the generating capacity's optimal structure (see figure 4).

3. Model of Linear Programing for Computing Optimal Charges

As has already been noted, restrictions on the parameters mix of power-station operation, expenditures on stops and starts, and so on, are not considered in the continuous-time model examined in the preceding section. Thus, the load of the base thermal steam electric-power stations cannot dip below the technical minimum, which is about 70 percent of their capacity, and AES's (in the absence of a regulating load) work only at full capacity. The optimal structure of the capacity and their loads that are obtained in accordance with the continuous-time model cannot meet these restrictions. Moreover, it is difficult to construct a continuous-time model for determining differentiated charges by day of the week and by season. In order to account for these factors a

simpler linear model is proposed in which the moments that separate the time zones are considered beforehand as prescribed.

Let us cite a formulation of a static problem of linear programing for expanding and using the capacity of steam power stations of various types in an OES in order to satisfy the given requirement in a computed year of the plan period, in each time zone of a typical load schedule of an OES, given the minimum total expenditures

$$\sum_{i=0}^{n} \Pi_i x_i + \sum_{i,j,k} q_{ik} y_{ijk} \to \min, \tag{7}$$

$$y_{ijk} \leq h_{jk}(\bar{X}_i + x_i), \tag{7'}$$

$$\frac{y_{ijk}}{h_{jk}} \geq \beta_i \frac{y_{i1k}}{h_{1k}}, \quad j=2,3,\ldots,m, \quad i=0,1,\ldots,n, \tag{7''}$$

$$\sum_{i} y_{ijk} = \ni_{jk}, \tag{7'''}$$

$$x_i \geq 0, \quad y_{ijk} \geq 0, \quad i=0,1,2,\ldots,n. \tag{7''''}$$

where i is the type of steam power station; j is the number of the daytime zone in the load schedule in terms of duration for typical days; k is the number of the type of typical days (workdays and nonworkdays of the winter and summer). The time zone (j, k) means the totality of j zones on all type k days; h_{jk} is the length of the zone (j, k); $\ni_{jk}$ is the requirement for energy in this zone; and j_{ijk} is the generation of energy by all type i power stations in the zone (j, k). Since all type k days are indistinguishable, the indicators h_{jk}, $\ni_{jk}$ and y_{ijk} can be expressed by the corresponding values which are computed for some days. Let us mark these same letters with accent marks. Then $h_{jk} = n_k h_{jk}'$ and $\ni_{jk} = n_k \ni_{jk}'$, ..., where n_k is the number of type k days per year; Π_i is the same as it was in task A (see section 2); q_{ik} are the specific costs of fuel for generating 1 kWh of electricity by type i capacity on type k days (including expenditures for fuel for startup, idling and stops under the normal set of operating parameters; it is hypothesized that fuel expenditures do not depend upon the zone of the day); β_i is the coefficient that characterizes the relationship of the technical minimum of the workload to the nominal capacity of i-type electric-power stations; and $\bar{X}_i$ is the type i capacity that is operating at the start of the plan period. Being sought are y_{ijk}, and also the capacity x_i of newly built i-type power stations. The permissible sets of operating parameters are considered in the inequalities of (7''), which actually signify that the type-i capacity that is used in the zone j of a type k day should be not less than the technical minimum of type-i capacity that is operated in the peak zone of those same days. For AES's the relationships (7'') are given as an equality. Such restrictions on the number of base KES units based on fossil fuel that are turned off on nonwork days can be considered in the problem.

The models do not reflect clearly the balance of capacity, since it ensues from (7')-(7'''). If, in the given OES, crossflows of capacity and energy from other OES's play a significant role, then these crossflows can be considered as a special form of generating capacity of the appropriate type in the given OES.

The following dual problem corresponds to the cited straight problem of linear programing

$$\sum_{j,k} \text{Э}_{jk} p_{jk} - \sum_{i,j,k} h_{jk} \bar{X}_i r_{ijk} \to \max, \tag{8}$$

$$\sum_{j,k} h_{jk} r_{ijk} \leqslant \text{П}_i, \tag{8'}$$

$$p_{jk} - r_{ijk} + u_{ijk} \leqslant q_{ik}, \tag{8''}$$

$$p_{jk} \geqslant 0,\ r_{ijk} \geqslant 0,\ u_{ijk} \geqslant 0, \tag{8'''}$$

$$i = 0, 1, \ldots, I,\ j = 1, \ldots, J,\ k = 1, \ldots, K,$$

where r_{ijk} is the rental-equivalent evaluation of 1 kW of i-type capacity per hour of operation in the zone (j, k); u_{ijk} are the evaluations of restrictions on sets of operating parameters (7''); p_{jk} is the optimal evaluation of 1 kWh that is consumed in the zone (j, k); and the values of p_{jk} are interpreted as long-range cost evaluations (optimal charges) for the electricity.

The basic computations were performed for four types of electric-power stations: AES's (i = 0), GTU's [gas-turbine units] (i = 1), adjustable semipeak-power) KES's [condensing power stations] (i = 2), base KES's (i = 3). AES's and base KES's should operate each day on the base sets of operating parameters. Accordingly, J = 3. The problems (7)-(7'''') and (8)-(8'''') were constructed for four types of days (k = 1, ..., 4) for the typical daily load schedules that correspond to them, the length of the time zones for each type of day being given previously (by means of the broken line of minimal expenditures $\text{З}(t)$, see the preceding section). Both problems--direct and dual--can be used for determining the optimal length of the time zones h_{jk}. For this purpose, the model (7)-(7'''') for graduated load schedules with 1-hour duration of each step, that is, assume $h_{jk}' = 1$ hour, should be examined. This will be an approximation of continuous-time models. On the basis of both models one can determine the length of the time zones of the annual load schedule, and also the optimal structure for generating capacities. Optimization calculations indicate that in the self-balancing OES's, as a rule, the following conditions, which characterize a typical situation, are met: 1) new capacity of electric-power stations of each type, which limits the corresponding zone of the load schedule, that is, i = 0, 1, ..., n; are introduced; 2) the electricity should be generated only by electric-power stations that are economical for the given zone, that is, $y_{12k} = y_{13k} = y_{23k} = 0$, k = 1, ..., 4; the inequalities (7') are carried out as strict ones and therefore $r_{12k} = r_{13k} = r_{23k} = 0$ (the corresponding rental-equivalent evaluations are equal to zero); and 3) during the winter nonwork days and summer days there is in each time zone unloaded electric-power station capacity which limits winter workdays to one time zone or another of the daily load schedule, and the rental-equivalent evaluations also are equal to zero.

Work [5] examines the simplest case of the models (7)-(7'''') and (8)-(8'''), when the various types of days (k = 1) are not singled out, three types of electric power stations (I = 3) and, accordingly, three time zones for the days (J = 3) are operating. It is assumed that the restrictions (7'') are absent (they are always fulfilled in the optimal plan) and therefore

$u_{ijk} = 0$. In this case, in the typical situation (if conditions 1) and 2) are met), the inequalities (8')-(8''') are transformed into a system of equalities which determine unambiguously the values r_{ij} and p_j in the form of simple algebraic functions from q_i, Π_i and h_j. Under a 12-charge schedule and four types of stations, the typical situation also permits the values of the optimal charge to be obtained without solving the linear programing problem (see section 4).

In the optimal solution, base KES's can produce surpluses of power in the nighttime zone of the winter days, when the requirement for it proves to be below the technical minimum of the load of the base power units (daily switch-off of these at night is impossible, but on nonwork days this is permissible for a limited number of times per year). The surplus of power in the nighttime zone, which is mandatorily generated by the base units, can be used effectively by regular customers who need the energy only at nighttime or during the valley hours on the load curve.

The main types of regulator customers are the pumped-storage electric-power stations (GAES's). They receive power for filling up the upper reservoir and generate it during peak hours. Moreover, the regulator customers also act as pumping stations and industrial units, which can operate at reduced load during peak hours and with an increased load during night hours.

The methods for determining differentiated rates for electricity that have been examined are based upon assumptions about the possibility of covering the prescribed load schedule. However, often there are situations wherein the capacity at the disposal of some power systems does not allow the national economy's energy requirements to be met completely. According to studies that have been made, in such cases the damage to the national economy usually exceeds 5-fold to 10-fold the costs for producing 1 kWh [7]. According to the theory of optimal planning, the optimal charge in this situation should reflect not the expenditures for producing the energy but should equal the specific harm caused by the shortfall for each kWh of power [4]. Both the regulator customers and the shortage of power can be considered by modifications of the linear model (7)-(7'''') and (8)-(8''').

It follows from the solution of model (8)-(8''') that in the normal situation (where there is no shortage of capacity or of energy), payment for capacity (or the corresponding increased charge in the peak zone for 1 kWh) is levied only in the peak zone of the winter workdays, while for the various time zones (under an optimal breakdown thereof) of typical days of all types, the charge will be equal to the fuel component of the electric-power station of that type that limits this zone. In the case when the main customers' requirements prove to be lower than the technical minimum of the base power station loads and surplus electricity must be generated (for example, during nighttime winter workdays), the charge equals the specific benefit of the limiting regulating customer.

4. Determination of a 12-Charge Schedule for Electricity

As has already been noted, the conditions for consuming electricity vary sharply not only by time of day but also by type of day (workday or nonwork day) and by season of the year. Differentiation of the charges by day of

the week and season motivates customers to place the load on unused capacity during all periods, except winter workdays. This enables the national economy to get a substantial benefit in comparison with a charge differentiated only by the time-of-the-day zone, but not by type of day. Below we examine an arbitrary numerical example of the use of the models proposed in the preceding section for determining a 12-charge schedule. The notation introduced in section 2 is used. Recommendations which reflect the typical situation for OES's of the European part of the country are used. At present new base KES's (BKES's) that operate on organic fuel are not being put into operation, while the existing BKES's which were forced out from the nighttime valley zone (that is, the base operating-parameters zone) by new AES's, limit the so-called evening and night-time zone (the semibase operating-parameter zone) of the annual load schedule in terms of endurance. It is assumed that the AES's operate the year around with a complete load in the base operating-parameter zone, and that the adjusted costs for them will not be a function of the number of hours of operation: $З_4$ = 131.8 rubles/kW (table 1). It is assumed that the maximum benefit of the regulator customers in the nighttime valley zone (see section 3) equal zero. It is possible that the AES's will produce surplus power in the nighttime valley zone. The existence of peak and semipeak power stations is not considered.

Table 1

Technical and Economic Indicators for Electric-Power Stations

No. of type of station i	$K_i^З$, rubles/kW	Type of fuel	Standard limit costs per kg of standard fuel equivalent, kopecks/kg of standard fuel equivalent	Fuel expenditures, q_i	
				Per kg of standard fuel equivalent/kWh	In standard limit costs, kopecks/kWh
1	90	Gas	5.0	0.45	2.25
2	140	Coal	3.6	0.40	1.45
3	170	Coal	3.6	0.33	1.20
4	400	Nuclear fuel	-	-	0.50

Let us examine a typical situation, wherein the requirements for electricity in each zone are much higher for the winter workdays than for a day of any other type (see [7]). Since the optimal share of the GTU's, as a rule, are always less than 10 percent of the maximum of the winter workdays and they have greater specific fuel consumption than adjustable and base KES's, the GTU's for the other types of days are withdrawn from operation. The demands for power D_{jk} by zone of the day j of the type k are given in table 2.

Table 2

Requirement D_{jk} for Capacity in the Zones (j, k) in Shares of Maximum Load of the Power System

Zone of the day j	Type of day, k			
	Winter workday	Winter nonwork day	Summer workday	Summer nonwork day
Peak	1	0.85	0.75	0.65
Daytime	0.9	0.70	0.65	0.55
Nighttime	0.7	0.60	0.50	0.4

Figure 5 shows the load schedules in terms of duration: the annual D(t), winter workdays $D_1(t)$, the winter nonwork day $D_2(t)$, summer workdays $D_3(t)$ and summer nonwork days $D_4(t)$.

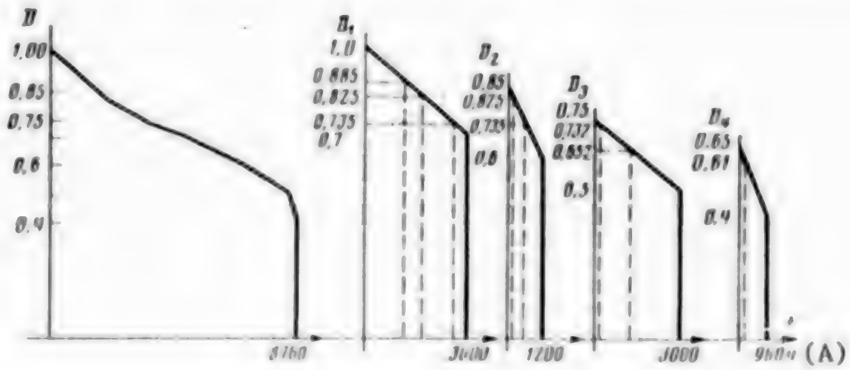
The annual schedule D(t) is a piecewise-linear function of t and is constructed by summation of the length of use of each value of the capacity D for all the prescribed trapezoidal schedules $D_k(t)$ for typical days of the type k, k = 1, ..., 4. For D(t) we find the optimal duration of operation of electric-power stations of various types and the structure of the generating capacity in accordance with the model set forth in section 2, on the basis of the structure of the broken line of minimal expenditures $\mathfrak{Z}(t)$ and solution of the corresponding system of equations (6).

In our example, the optimal length of use of the peak power of the GTU's based on the annual load schedule D(t) is 1,375 hours, the semipeak power of the MKES's [flexible KES's] 2,340 hours, base-load BKES's 8,060 hours and AES's 8,760 hours. The following structure of generating capacity corresponds to the values obtained for endurance: GTU's 11.5 percent of the minimum power-system load D(0), MKES's 6 percent, existing BKES's 30 percent (the prescribed value), and AES's 52.5 percent. These capacities are situated on the load curve D(t) from the top on down in the order of decrease of the specific cost of the fuel q_i.

The length of the time zones for the schedules for duration of the load for various types of days is determined by their intersection with the straight horizontal lines, the ordinates of which separate the capacities of the various types on the annual schedule D(t) (taking into account the potential for reducing the base stations' load to the technical minimum, see figure 5). The lengths of the time zones thus obtained are shown in table 3.

Figure 5. Trapezoidal Load Curves for the Duration of Characteristic Days.

A. 960 hours.



In the case when the MKES's and BKES's are limited in the peak zone, the specific fuel consumption thereat increases (in the example, an increase by about 10 percent is assumed) in comparison with their normal set of operating parameters. The increase is caused by the need to connect up these electric-power stations in anticipation of covering a sharp load increase during peak hours and by the need for additional fuel expenditures caused by idle running, which is reflected in the charge. In computing the duration of use of capacity of each type approximately, the nonlinear dependence of of specific fuel cost on the number of hours of power consumption is

Table 3

Optimal Charges and Length of Time Zones*

Zone of the day, j	Type of day, k			
	Winter workday, 150 days (3,600 hours)	Winter nonwork day, 50 days (1,200 hours)	Summer workday, 125 days (3,000 hours)	Summer nonwork day, 40 days (960 hours)
Peak	GTU[1]; 2.25 / 9; 1,375	MKES[2]; 1.6 / 2.4; 120	MKES; 1.6 / 1; 120	BKES[3]; 1.32 / 5; 200
Daytime	MKES; 1.45 / 5; 725	MKES; 1.2 / 8.6; 430	BKES; 1.2 / 7.6; 960	
Nighttime	BKES; 1.2 / 7; 1,080	BKES; 0 / 13; 650	BKES; 0 / 15.3; 1,920	BKES; AES[4]; 0 / 19; 760
	BKES; 0 / 3; 420			

*Type of limiting electric-power station and the charge payment p_{jk} (kopecks/kWh) is the numerator, and daily annual duration of the zone (hours) is the denominator.

1. GTU: Gas turbine unit.
2. MKES: Flexible condensing electric-power station.
3. BKES: Base-load condensing electric-power station.
4. AES: Nuclear electric-power station

considered. As has been indicated, the charge in each zone is the specific cost of the fuel for the power station of the type that limits this zone (see table 3). In the peak zone of a winter workday, another fee is exacted for the power consumed per hour of the maximum load; in our example this fee is 38.2 rubles/kW.

During the computations, the fulfillment of operating-parameter restrictions is also verified. On winter workdays, during the nighttime hours, the BKES's are on the technical load minimum, which is 0.21 D(0). The total share of AES capacity is (0.525 D(0)) and the technical minimum of the BKES's load is 0.735 D(0). This value is greater than the minimum of the winter daytime load; it is 0.7 D(0). Therefore, during the nighttime hours, the BKES's will be compelled to produce surplus energy. The length of use of BKES's on a winter workdays, equal to 3,180 hours, corresponds to the value of D = 0.735 D(0). Since the length of operation of a semipeak station on winter workdays is 2,100 hours (in table 3, the sum of the daily daytime and nighttime zones), then in the zone (2,100 and 3,180 hours) the BKES's gradually reduce power to the technical minimum. Let us call this zone the evening-nighttime zone of the load curve $D_1(t)$ and we determine its length as 1,080 hours (7 hours per day). In the zone 3,180 and 3,600 hours) the BKES's are compelled to produce a surplus of energy. We call this zone the nighttime valley zone, with a duration of 420 hours (about 3 hours per day), where the charge is the maximum benefit of the regulator-customer. It is zero in the example being examined.

In table 3, in the third line for the winter workday, the durations and charges for the evening-nighttime zones are shown; these limit the BKES's and the nighttime valley zones, where the BKES's produce a surplus of energy.

Similar computations were made for other types of typical days, and the results thereof are incorporated in table 3. Let us note that on summer nonwork days, the peak-power zone, which is limited by the BKES's, the offpeak daytime zone, which is limited by the BKES's which operate on the load's technical minimum and mandatorily generate a surplus of energy, and the nighttime valley zone where the AES's are the limiters, are singled out. Since the charge in both cases is equal to the maximum benefit of the consumer-regulators (in the example given it is zero), both of these zones are combined into one offpeak zone. It is proposed that the calculations for nonwork days be established at 10 percent of the BKES's power units which operate on fossil fuel and that in the summer 10 percent of the capacity of the electric-power stations of each type be withdrawn for overhaul.

5. Questions of Improving the Methodology for Establishing Limit Costs and Optimal Charges.

According to work [1], the standard for limit costs $\phi^{\text{э}}(h)$ per 1 kW of electricity corresponds to the customer's actual set of operating parameters and is defined as the weighted average of $\phi_{\delta}^{\text{э}}$ and $\phi_n^{\text{э}}$ of the specific adjusted costs for generating electricity by electric-power stations that restrict the base and peak operating (horizontal) zones of the load curve (the notation in [1] is used)

$$\varphi^{\text{э}}(h)=\frac{h_{\delta}(h-h_{n})\varphi_{\delta}^{\text{э}}+h_{n}(h_{\delta}-h)\varphi_{n}^{\text{э}}}{(h_{\delta}-h_{n})h}, \tag{9}$$

where h is the annual number of hours of operation of the electricity-consuming equipment of the category of customers that is being examined when it is under full load (more precisely, the energy requirement divided into the electrical capacity of the equipment); h_{δ} and h_n are the annual number of hours of operation of the base-load and peak-load power stations when they are under full load (that is, the amount of production of electricity divided by their nominal capacity), h_{δ} = 7,000 hours and h_n = 1,000 hours. This formula operates over the interval $h \in [h_n, h_{\delta}]$. If $h < h_n$, then $\phi^{\text{э}}(h) = \phi_n^{\text{э}}$.

For substantiation of formula (9), the assumption that the customer also is operating at maximum load during the period of the power system's maximum load is essential. However, this assumption is not always borne out.

The expenditures of power stations that cover the semipeak zone are not considered in (9). The value of the expenditures obtained according to (7) can differ substantially (by 20-30 percent) from those of semipeak-load power stations for the very same number of hours of operation (3,000,4000 hours per year).

This defect was corrected by means of two formulas for weighting, similar to (9), for the cases $h \in [h_n, h_{nn}]$ and $h \in [h_{nn}, h_{\delta}]$, where h_{nn} is the annual number of hours of operation of semipeak power stations (at full load). In this case $\phi^{\text{э}}(h)$ is defined as the weighted average from, respectively, $\phi_n^{\text{э}}$ and $\phi_{nn}^{\text{э}}$, and $\phi_{nn}^{\text{э}}$ and $\phi_{\delta}^{\text{э}}$ ($\phi_{nn}^{\text{э}}$ are the specific expenditures for semipeak stations). However, this variant assumes that the maximum load of the customer coincides with the power system's maximum load. If, for example, the electrical consumption schedule covers only the daytime and nighttime

zone, then the proposed formulas, just like (9), will yield values for $\delta^{\flat}(h)$ that are considerably overstated.

Work [6] proposes that measures for customer participation in a power system's maximum load in the form of some coefficient of addition of the customer's maximum load to the power system's maximum be considered. In practice, this is difficult, since there is no precise method for computing such a coefficient. Also, questions of differentiation of limit costs for electricity by day of the week and by season are not examined. The indicated difficulties can be avoided where we account for nonuniformity of electrical consumption in terms of time (vertical), as work [6] proposed, but not in terms of operating-parameter (horizontal) zones of the load curve. The limit costs (and optimal charges) for electricity must also be determined by time zone.

FOOTNOTES

*The numbers of newly built i-type stations correspond mutually and unambiguously to the numbers j of existing stations of the same type.

**In (6) the duration of operation of newly introduced stations j of the i type are signified by t_j, the existing stations by $\bar{t}_j$.

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UkSSR POWER MINISTER ON IMPROVED SUPPLY OF ELECTRICITY

Kiev ENERGETIKA I ELEKTRIFIKATSIYA in Russian No 1, Jan-Mar 87 pp 2-6

[Article by V.F. Sklyarov, UkSSR minister of Power and Electrification: "Increasing the Reliability of Electrical Power Through Improving the Economic Mechanism of Administration"]

[Text] The course toward accelerating social-economic development, drawn up by the April (1985) Plenum of the CPSU Central Committee and the 27th Party Congress, and the process of comprehensive reorganization of our society urgently require further improvement in the economic mechanism of administration of all sectors of the national economy, with their subsequent transition to full cost accounting and self-financing.

The "Basic Directions for the Economic and Social Development of the USSR in 1986-1990 and the Period up to the Year 2000," approved by the 27th CPSU Congress, contain an entire group of measures to improve planning, increase the efficiency of economic levers and incentives and improve the organizational structures of administration. Constant, purposeful work is being carried out in all these directions in the electrical energy sector.

An important stage in preparing for the transition of the electrical energy sector of industry to full cost accounting was the conversion, beginning from 1 January 1987, of all the production energy associations and energy enterprises under their jurisdiction, to new conditions of economic activities. This was implemented in accordance with the decree of the CPSU Central Committee and USSR Council of Ministers of 12 July 1985 "on Widescale Dissemination of New Methods of Economic Activity and Intensification of Their Effect on Accelerating Scientific-Technical Progress." The main purpose of the conversion is to ensure a rise in the reliability and quality of the energy supply for the national economy on the basis of accelerating scientific-technical progress, consolidating economic accounting and expanding the rights and increasing the economic responsibility of the collectives of energy enterprises.

The system of economic activity is being reorganized on the basis of a rise in the role of the five-year plan for economic and social development, widescale use of stable economic norms and intensifying the effect of intraproduction

cost accounting on increasing the work activity of the collectives of shops, sections and brigades and of each worker, with a view to achieving high end results of the work of associations and enterprises. Beginning in 1987, it is specified that the five-year and yearly plans for economic and social development of the associations and enterprises of the USSR Ministry of Power and Electrification as well as of the ministry as a whole (for the Electrical Energy sector) confirm the following more precise formulation of indicators and limits:

Generating electrical energy including that for its structure (for the ministry);

Issuing thermal energy (for the ministry);

The coefficient of efficiency of using the rated power of electric power plants (for electric power plants--the amount of operating power)

The industrial consumption of electrical energy for transmission along power networks;

The growth of labor productivity, calculated according to the coefficient of service of the rated power (for associations and enterprises);

Profit;

The basic assignments for developing, creating, introducing and expanding the use of new equipment and technology;

The basic assignments for environmental protection and efficient use of natural resources;

The wage fund for industrial-production personnel of associations and enterprises serving the electrical and thermal networks (for the ministry);

The wage fund for nonindustrial personnel;

The limits of state centralized capital investments and construction and installation work and putting into operation fixed capital, production capacities, apartment houses and other objects for social purposes by means of these capital investments;

The limits of material-technical resources (for an expanded products list)--in the five-year plans, and funds for basic types of material-technical resources--in the yearly plans;

The assignments for the average lowering of the norms for consumption of the basic types of material-technical resources--in the yearly plans;

In addition, in the five-year and yearly plans, the relative consumption of conventional fuel per unit of electrical energy issued from the busbars of the thermal electric power plants (estimated) is established for the associations and enterprises, as well as for the ministry as a whole, and for the

electric power plants in the yearly plans--the consumption of electrical energy for their own needs to produce electrical and thermal energy (estimated). To determine the dynamics of production development and evaluate the structural correlations and sectorial and territorial proportions, the growth rate of commodity production (estimated) is also established. The volume of production sold (estimated) is established in the yearly plans for the associations and ministry.

It should be borne in mind when working out the plans that the wage fund for the workers of enterprises and objects newly put into operation, as well as the material incentive fund and the fund for social and cultural measures and housing construction, are specified separately in the five-year and yearly plans. The volumes of capital investments, construction-installation and contracting work, as well as putting into operation fixed capital, production capacities, apartment houses and other objects for social purposes through the capital from the production development fund and the fund for social and cultural measures and housing construction, are taken into consideration in the plans of the ministry in accordance with the suggestions of the associations and enterprises.

With a view to expanding the use of economic norms in planning the sector's activity, beginning in 1987, in the five-year plans for the associations and enterprises, as well as for the ministry as a whole, the following economic norms are approved:

Payments for production funds (for associations and enterprises);

Withholdings from the estimated profit for the state budget--in the yearly plans;

Withholdings from the estimated profit for the ministry's reserve fund--in the yearly plans (for associations and enterprises);

The wage fund for industrial-production personnel of associations and enterprises, with the exception of those serving the electrical and thermal networks, per unit of rated electrical and thermal power (for associations and enterprises);

The wage fund for industrial-production personnel of associations and enterprises serving the electrical networks--per 100 kilometers of electric power transmission lines, and the thermal networks--per 1 kilometer of heating systems (for associations and enterprises);

The wage fund of supervisory, engineering-technical personnel and employees;

The wage fund of designers, technicians and scientific personnel (for associations and enterprises);

Formation of a fund for production development;

Formation of a fund for social-cultural measures and housing construction;

An increase in the material incentive fund for each percent of increase in the coefficient of efficiency of using the rated power of electric power plants;

Formation of a unified fund for the development of science and technology (for the ministry).

The USSR Ministry of Power and Electrification and the ministries of Power and Electrification of the union republics have been permitted to establish a normative correlation of the increase in the average wage with the increase in labor productivity for associations and enterprises, for whom goals for a labor productivity increase have been approved. The norm for the increase in the wage fund for industrial-production personnel of associations and enterprises, with the exception of those serving the electrical and thermal networks, for each percent of increase in commodity production, has been established in the five-year plans for the USSR Ministry of Power and Electrification as a whole.

Other indicators and norms, more fully reflecting the specific features of their production and economic activity, can be established for the associations and enterprises engaged in repair and adjustment work and for energy supervision enterprises.

The USSR Ministry of Power and Electrification and the ministries of Power and Electrification of the union republics may differentiate the economic norms according to individual associations and enterprises. The economic norms established in the five-year plans are not subject to change.

On the basis of the approved indicators, limits and economic norms, the energy associations work out the five-year and yearly plans for economic and social development and the finance plans independently. At the same time, the yearly plans are worked out by the ministry, associations and enterprises of the sector on the basis of the assignments of the five-year plan for the corresponding year.

With the transition to the new conditions of economic activit the rights of the energy associations with respect to wages are considerably expanded.

With a view to intensifying the relationship of personnel wages to the final results of the work of the labor collectives, the wage fund for industrial-production personnel of associations and enterprises is formed on the basis of the approved indicators and norms.

At the same time, the energy associations and enterprises are permitted to increase the wage fund of the nonindustrial personnel through the planned wage fund for industrial-production personnel, calculated according to the norm.

The unused total of savings for the wage fund of associations and enterprises is transferred at the end of the year to the material incentive fund through the profit remaining at their disposal, under the conditions of observing the

coefficient of efficiency of using the rated power of the electric power plants (for electric power plants--the operating capacity) and assignments for increase in labor productivity established in the plan.

Energy associations can create a reserve for the wage fund amounting to 1 percent of its planned (estimated) value. When the actual wage fund exceeds the planned, (estimated), it is permissible to use part of the material incentive fund (when there is insufficient saving of the wage fund for the current year) upon agreement of the work collectives. The amount by which the wage fund exceeds the planned (estimated), replaced from the indicated sources of these associations and enterprises, is not regarded as overexpenditure of the wage fund.

One of the most important levers for ensuring fulfillment of the tasks set by the party is the universal development of the labor and creative activity of the workers to accelerate the rates of economic growth. An integral component of the new economic mechanism is improvement in the organization of wages, implemented at energy enterprises in accordance with the decree of the CPSU Central Committee, the USSR Council of Ministers and the All-Union Central Trade-Union Council of 17 September 1986. The ultimate aims of this work are, on the basis of a fundamental reorganization of wages, bonus-award systems, introducing new wage rates and salaries and, supported by widescale use of the powers specified by the USSR Law on Labor Collectives:

To attain the direct relationship of the wages of all the workers to individual and collective results of labor;

To eliminate elements of wage leveling;

To eliminate all cases of obtaining unearned money and eliminate write-ups;

To improve the correlations in the wages of workers of different categories, ensure advantages in the payment of highly skilled workers and other specialists and raise the prestige of engineering work;

To increase the role of the collectives of all structural subdivisions of an enterprise (shop, section, division) in evaluating the work contribution of personnel to the overall results on the basis of using normative methods of forming the funds for the wages and expanding their independence in the use of the funds for material incentive for the workers, particularly in improving intraplant cost accounting.

In this connection, the efforts of all the work collectives should be concentrated on maximum mobilization of intraproduction reserves to create the necessary resources for the increase and improvement of wages. Permission has been given to direct the entire saving of the wage fund, including the saving obtained through reducing the number of personnel, improving the wage structure, revising the norms for output and other labor input norms, paying bonuses, additional and supplementary payments, toward raising wage rates and salaries. At the same time, it must be borne in mind that the saving of the wage fund obtained

through eliminating unnecessary administrative units, consolidating enterprises, organizations and their structural subdivisions and also carrying out other measures to reduce the number of workers in the administrative apparatus, is not subject to immobilization and can be fully directed toward raising wage rates and salaries.

Very serious attention should be paid to a constant improvement and increase in the effectiveness of the entire system of economic and moral stimulation of the highly productive work of energy enterprise personnel. In particular, on the basis of the system of economic stimulation of the operations personnel, three basic principles should be laid down: a maximum increase in the use of production capacities, heightening the reliability of the work of power equipment and reducing its accident rate, and the end results of work to raise the degree of saving of energy production.

The directors of associations and enterprises have been granted the right to approve the administrative structure of associations and enterprises.

The material incentive fund for energy associations is formed on the basis of the size of this fund, determined from the plan for the base year, and the sums of the accretion of the fund, calculated according to the established norms for the coefficient of efficiency of using the rated power of electric power plants.

In order to stimulate the growth of labor productivity according to the results of work for the year, additional withholdings for the material incentive fund are made according to the norm, amounting to 2.5 percent of the planned amount of this fund for each percent of increase in the coefficient of service of the rated power as compared with the level achieved by it in the base year, on condition of the fulfillment of the planned assignment for labor productivity increase. It is also permissible to make additional withholdings for the material incentive fund of associations and enterprises amounting to 70 percent of the cost of the fuel saved in the actual prices of the period under review, with a view to stimulating economical consumption of fuel-energy resources.

At the same time, in order to increase responsibility for reliable energy supply to the national economy, it is specified that the material incentive fund of the associations and enterprises of the USSR Ministry of Power and Electrification be reduced by the sum of the fines paid for issuing electrical energy in an amount lower than the quarterly limits established for the consumers, and also of poorer quality (other than the frequency of the electric current), but not over 20 percent of the planned amount of this fund, specified for the corresponding quarter.

The fund for social and cultural measures and housing construction of the associations and enterprises of the USSR Ministry of Power and Electrification is formed in accordance with stable norms, in percentages of the material incentive fund. The capital of this fund, accumulated by the associations and enterprises, is not subject to immobilization and is used in specific directions directly determined by the work collectives.

The directors of the associations and enterprises are permitted to turn over, with the agreement of the work collectives on the basis of share participation, the capital of the fund for social and cultural measures and housing construction to the ispolkoms of the local soviets of people's deputies and to other organizations and enterprises, for construction of objects for a direct purpose and primarily for apartment houses. When five-year and yearly plans are worked out, it is also permissible to specify the direction, with agreement of the work collectives, of part of the capital of the material incentive fund into the fund for social-cultural measures and housing construction, to be used to finance the construction of apartment houses and other objects for social purposes.

The fund for developing the production of the associations and enterprises of the USSR Ministry of Power and Electrification is formed by depreciation deductions for the full regeneration of fixed capital, withholdings from the profit in accordance with established norms, and also the proceeds from selling excess property.

When approving the norms for forming and determining the directions for using the fund for development of production, it should be taken into consideration that financing state capital investments for technical re-equipment and renovation of existing production facilities is implemented only through the capital of this fund. When there is not enough capital in the fund for these purposes, bank loans are drawn. The capital from the fund for production development may be accumulated by the associations and enterprises to implement the necessary measures in the following planning periods, and is not subject to immobilization. The banks pay the associations and enterprises percentages for use of the provisionally free capital from their production development fund.

The associations and enterprises are granted the right to independent use of part of the capital from the unified fund for the development of science and technology to carry out, on their own initiative, scientific research and planning and design work on creating and introducing new equipment, as well as for compensation of increased expenditures in the period of its development.

In relation to the sectorial features of energy production, in practice there may be cases when the plan for profit is not fulfilled for reasons unrelated to the work of the energy association collective. In view of this, it is specified that when there is a shortage of the profit left at the disposal of the associations and enterprises of the USSR Ministry of Power and Electrification, in connection with a reduction in the output of electrical energy at the hydroelectric power plants, a change in the volume of production of electrical and thermal energy as the result of a change in the actual level of its consumption and the structure of the fuel used, or a reduction in the basic payment by group of consumers with a connected power of 750 kV·A and over, the sum of the excess of fines obtained above those paid remains (with the permission of the ministry) at the disposal of the associations and enterprises for an addition to the material incentive fund and the fund for social and cultural measures and housing construction in accordance with the approved norms.

The energy associations introduce payments from the profits to the state budget independently (decentralization) and can, by virtue of the profit remaining at their disposal, form financial reserves amounting to 5 percent of the norm of their own working capital.

In the USSR Ministry of Power and Electrification and the ministries of Power and Electrification of the union republics, in accordance with stable norms, a reserve fund is formed, the capital from which is directed toward:

Financing the planned expenditures of planned-unprofitable and low-profit associations and enterprises within the subsidy limits established for them;

Financing scientific research and planning and design work and other expenditures of a general sectorial nature (into the unified fund for development of science and technology);

Creating reserves for the material incentive fund and the fund for social and cultural measures and housing construction;

Rendering temporary financial assistance to associations, enterprises and economic organizations and for other purposes.

For economic incentive to improve the use of material resources, energy associations are obliged to introduce into the budget an additional payment amounting to 3 percent of the cost of the above-norm reserves of commodity-material values and uninstalled equipment, not extended credit by the bank.

Organizing the work of energy enterprises under the new conditions of economic activity requires from directors of all administrative levels of the sector more fixed attention to the problems of improving planning on the basis of widescale use of stable economic norms, fundamental reorganization of the work of the system, reinforcing executive and planning-financial discipline, intensifying exactingness toward personnel for the section of work entrusted to them, establishing effective control over the efficient expenditure of the wage and material funds and deepening the economic analysis of the end results of work collective activity. In directing the standard statute on organizing the intraproduction cost accounting of the associations of the USSR Ministry of Power and Electrification (for the "Electric Energy" sector), the further expansion and reinforcement of cost accounting, right down to sections and brigades, must be ensured everywhere.

In conjunction with party and social organizations, the necessary explanatory work on problems of the activity of enterprises under the new conditions of economic activity and improvement of the organization of wages and work incentive should be actively carried out in each work collective. In all units of energy economic activity there must be a rise in the level of economic training for personnel, guarantee of constant, active monitoring of the reliability of report data, with particular attention paid to newly introduced indicators and improvement in the organization of socialist competition and exchange of advanced experience in economic operations.

An active search for intraproduction reserves, widescale use of economic administrative methods, a high degree of organization and discipline and full-yield work from each person--these are the paths leading to the strengthening of the economic sector and genuine success in fulfilling the tasks set for the energy workers by the 27th CPSU Congress.

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ACCIDENT PREVENTION TRAINING FACILITY DESCRIBED

Kiev ENERGETIKA I ELEKTRIFIKATSIYA in Russian No 1, Jan-Mar 87 pp 44-46

[Article by V.A. Gureyev, candidate in technical sciences, and O.V. Suleymanova, engineer, GIVTs [Main Computer Information Center] of the UkSSR Ministry of Power and Electrification: "Developing the Architecture for a Mini-Base of Accident-Prevention Training Knowledge"]

[Text] Under the present conditions of the development of energy production, which is characterized by a highly unpredictable operational situation, by the limited nature of resources and by incomplete knowledge, systematic and purposeful work with the operations personnel is becoming particularly important.

One of the most important forms of technical-production training of operations personnel is their participation in accident-prevention training (PT), designed to develop experience in eliminating accidents and the phenomena contributing to them.

In practical work, the effectiveness of accident-prevention measures is considerably reduced because of the complexity of reproducing, at actual facilities, the adequate conditions for the occurrence and spread of accidents, a scarcity of information for analyzing and identifying the past history of accidents and the limited possibilities for model study of the factor of unexpectedness in the arisal of problem, cause-and-effect situations.

Unfortunately, technical literature has not fully covered theoretical and practical methods of eliminating complex accidents. This is primarily because of the lack of automated systems for accumulating vocational knowledge and experience on this subject, as well as the complexity of the process of transmitting knowledge from man to computer.

This problem can be solved by working out a general approach to methods of eliminating accidents on the basis of a systematic, purposeful approach to monitoring the organization of PT in the sector.

This work examines certain aspects of working out the architecture for a mini-base of knowledge for accident-prevention training, using TAR-34 personal micro-computers.

The information system performing the functions of the PT subject area should be oriented toward a relatively uniform collective of users--the operating personnel of electric power plants and networks.

The subject area of PT is a complex hierarchical system of interrelated technological and organizational functional levels.

Let us examine some of them in greater detail. The organizational level of the diagnostics of operations personnel includes a description of the information communications in electrical energy complexes and the entire sector as a whole, in the form of a semantic network.

This part of the subject area of PT is implemented by using a relational strategy of storing data, and consists of the relations: ministry, PEO [planning and economic division], TES, results, models, a list of PT, references, accidents, technological animated films, etc. For example, the following columns are specified in the "ministry" relation: PEO, the number of TES, units and operations personnel, current rating and list of specialties.

The structure of the models of this part of the subject area is standardized, and has the following characteristics: length, designation, detailing features and description of the algorithms for processing the models and converting the information.

Dialog support makes it possible to carry out the functions of correcting and merging--sorting, shaping and realizing inquiries on two levels: for the untrained user and for applied programs.

Orientation toward a two-level dialog system stems from the need to ensure information support both on the part of qualified process engineer specialists carrying out the technological loading and on the part of systems programmers, who modernize and develop the programmed realization of the knowledge mini-base.

The cause-and-effect level of the subject area of PT includes a description of the system for classifying the causes of accidents and accident-prevention measures, with a tie-in to objects and communicants. A network data base, in the form of a set of entries, each of which can refer to both several preceding (high-order) entries and to several subsequent (subordinate) entries, is used to implement this part of the subject area. An example is the violation of operations discipline, slackening of the attention and self-control functions and the incorrect sequence of operational actions of dispatcher I.I. Ivanov, when overcoming an emergency situation at the Oktyabrskaya substation on 18 July 1986 at 1730 hours (the basic state of the equipment, alarm system, position of the blinkers at the substation, communications and action of the OVB [floating operations brigade], etc. are described).

Dialog support makes it possible to carry out the functions of detailing cause-and-effect relations in the form of questions and answers and industrial systems of electrical energy equipment.

The information models for this part of the knowledge mini-base are also standardized and can be used for efficient formulation of multivariant PT scenarios.

The model level of the PT subject area is designed to organize technical-economic and optimization calculations at the actual PT rate. This part of the subject area is implemented by using a hierarchical strategy for storing the data, in the form of an ordered sequence of entries making up a multilevel system of data display.

Systems for substituting elements of the electrical energy complexes, programs for calculating the conditions and analyzing the results of equipment operation, certification data, etc. are stored at this level.

The information models have a flexible structure, which makes it possible to implement a random degree of detailization of the substitution systems, depending on the purposes and requirements for the calculations and the corresponding PT scenario.

This part of the data mini-base makes it possible to obtain new facts and conformities to principle existing in the PT subject area being examined, allowing for the state of the objects of the problem environment, but not recorded in the data base.

This approach to using information on the outside world offers the possibility of transition from a base of factual and quantitative data to a base of knowledge containing the conformity to principle of this subject area.

Access to the model level is implemented in the dialog mode when the above-enumerated service functions are realized.

Programs of interaction with models of the knowledge mini-bases and with synthesizers of situational and imitational simulators are concentrated at the program level of the PT subject area.

The representation level of the PT subject area is problem-oriented in nature, and is designed to display the information models of the mini-base on the screen in the form in which they are usually presented in technical literature.

Despite the informational and logical heterogeneity of the knowledge on the PT subject area, it has proven possible to work out a unified, all-purpose physical structure of the information model storage, based on configuration addressed references.

The control system of the knowledge mini-base uses as input information the certificate section of the index, which describes the general characteristics and relative displacement of the elements in the information models.

The knowledge mini-base architecture that has been worked out makes it possible to implement distributed information processing, using the local nets of a micro-computer.

With the aid of the software developed, technological loading of several PT scenarios has been implemented and trial introduction carried out at the Kiev TETs-5 and the Zaporozhye, Uglegorsk and Ladyzhinka GRES.

The knowledge mini-base developed is planned for widescale introduction as a part of the network of UTTs [educational-training centers] and UTP [educational-training programs] of the "Regional System of Instruction and Training of Operations Personnel at the Energy Enterprises of the UkSSR Ministry of Power and Electrification" in 1987-1990.

Conclusions

Personal micro-computers are being widely used in the tasks of instructing and training operations personnel.

Systematic, purposeful monitoring of PT organizations can be implemented on the basis of developed knowledge mini-bases which make it possible to automate the processes of accumulating and using occupational knowledge and experience in the PT subject area.

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TES OPERATIONS WITH LOW QUALITY COAL SOUGHT

Kiev ENERGETIKA I ELEKTRIFIKATSIYA in Russian No 1, Jan-Mar 87 pp 48-50

[Article by P.P. Bondarev, doctor of economic sciences, Yu. P. Korchevoy, doctor of physical and mathematical sciences, D.V. Atamanyuk and V.Ye. Tsvirkun, candidates in economic sciences, and Ya.S. Zholudov and V.A. Volkovinskiy, candidates in technical sciences, Lvov Polytechnical Institute, Division of High Temperature Conversions of Energy of the Institute of Problem-Solving Model Study in Power Engineering of the UkSSR Academy of Sciences: "Problems of Increasing the Operational Efficiency of TES With a Lower Quality of Solid Fuel"]

[Text] Despite the outstripping development of nuclear power, TES [heat and electric power plants] using organic fuel will remain the basic source of electrical and heat supply for the national economy in the near future [1]. In accordance with the USSR Energy Program, TES using organic fuel will be further developed for the long-range future [2]. The need for their operation is dictated by two important prerequisites: in the first place, by regulation of the capacities of the energy associations, including the ever-increasing capacities of the AES, and in the second place, by the use of resources of low-quality fuel and the wastes of the fuel-processing sector. The problems that have now built up in operating TES working on solid fuel are related to a reduction in the resources of high-quality hard coals in the European section of the USSR and to difficulties in extracting coal fuel and the long-observed lowering of the level of the quality of solid fuel. Since most of the presently existing TES will be in operation up to the year 2000, and the trend of lowering the quality of energy coals continues, the problem of their economical and efficient use in the future period is now pressing. With this perspective there must be more exact specification of the solid fuel resources according to the grades of the quality groups formed in consideration of the optimality of the technology for processing fuel of the corresponding quality.

Most of the TES of the UkSSR Ministry of Power and Electrification (79.5% of the established capacity) were designed to operate on solid fuel, and of them, 48.5% for operation on low-reaction Donets anthracites and lean coals and 31%--on the gas and long-flame coals of the Donets and Lvov deposits. The planned yearly consumption of conventional fuel for the TES is 49.4 million tons, and the actual, in 1985, was 29.2 million tons.

In accordance with the basic regulations of the USSR Energy Program for the long-range future, the main problem is to reduce the consumption of fuel oil. The proportion of coal should cease to be reduced, and should grow in the future.

The goals of the Energy Program, as well as the present-day requirements of scientific-technical progress pose a number of extremely important tasks for power engineering, the purpose of which is to increase the efficiency of using solid fuel, despite the trend toward lowering the quality level of the fuel supplied for TES, for the long-range future.

In future long-range planning of TES fuel consumption, the predicted indicators of fuel quality play an important role in selecting efficient, resource-saving, economically substantiated technology. The systemic approach forms the basis of this selection.

This article shows the results of studying the dynamics of the qualitative characteristics of solid fuel, up to the year 2000, the technical-economic indicators of TES operation related to them and the principal features of selecting efficient technology for solid fuel processing.

Data from TES, the UkSSR Ministry of Power and Electrification and also, in some cases, fuel suppliers, were used as the initial information. The data from the latter were used to construct dynamic series of the distribution of the weight of fuel, according to the grades of the qualitative indicators, and these series were then used to determine the relative volumes for the quality groups.

The indicators for the ash content A^p, the moisture content W^p and the heat of combustion of the working lowest Q^p_H of fuel were approximated by rectolinear regression equations in relation to the time. The predicted values for the qualitative characteristics of solid fuel for the UkSSR Ministry of Power and Electrification, by years, are given in Table 1.

Table 1

Designation of coal deposits (basin)	Quality indicator by years					
	1985			1990		
	Q^p_H, ккал/кг [1]	A^p, %	W^p, %	Q^p_H, ккал/кг [1]	A^p, %	W^p, %
Donets	3926	38.34	9.28	3513	43.25	9.89
Lvov-Volyn	4150	33.78	11.0	3580	37.57	11.5
Total for UkSSR Ministry of Power and Electrification	3878	38.79	9.3	3422	43.35	10.01

[1] kcal/kg

The combustion heat of solid fuel is reduced by an average of 0.385 MJ/kg a year or by 92 kcal/kg a year (Table 2). Because of the increase in supplies of concentrates of power-generating coals to TES in the period from 1982 to 1985, the rates of reducing the working ash content and combustion heat of the coal fuel were somewhat reduced.

Table 2

Designation of groups of coal grades and deposits	Reduction in boiler efficiency, gross per 1% of increase in coal ash content, in %	Increase in electrical energy consumption for internal needs (in % of output) per % of ash content
Donets basin		
Gas and long-flame (G, D)	0.210	0.126
Anthracites (ASh)	0.223	0.073
Lean (T)	0.172	0.085
Lvov-Volyn (L-V)	0.180	0.100

As the result of the change in quality of solid fuel, there is also a change in technical-economic indicators such as the efficiency of the boiler unit, the electrical energy consumption for internal needs, increase in the length of time for repairs, etc. The changes in the relative values of individual indicators for the coal units per 1 percent of the change in the working ash content of solid fuel are given in Table 2 (the data were obtained as the result of analyzing the work of nine GRES of the UkSSR Ministry of Power and Electrification in the period from 1970 to 1979).

The lowering of the quality level of solid fuel should obviously be compensated for by action of the opposite effect, that is, through raising the level of quality of the fuel, increasing additives of high-quality fuel or raising the technical level of the fuel-using units and adapting them to consumption of a lower quality fuel.

Correlation of the actual qualitative level of fuel with the level of the technology applied to fuel use at present can be achieved in the following directions:

Improving the quality of the fuel supplied to TES through enriching it;

Introducing new fuel-using technology, capable of processing low-quality fuel;

Partial substitution of solid fuel for natural gas or furnace fuel oil.

Raising the fuel oil consumption is considered unpromising in the light of the tasks of the Energy Program.

A comparison of the effectiveness of using various directions for the purpose of optimization should be made in accordance with a modified formula of adduced expenditures, taking into consideration the increase in expenditures for the electrical energy sector and the national economic loss from the under distribution of electrical energy to consumers, if it occurs with identical production effect. This model of adduced expenditures gives the correct interpretation of the phenomenon studied and makes it possible to compare the optimal variant of TES fuel supply in the future.

The technology of fuel processing in accordance with the TES design, when using solid fuel rated according to the quality level, is always the most substantiated and economically efficient. Increasing the gap between the levels of actual and rated quality leads to a loss of generating capacity, and additional expenditures are required in the electrical energy sector to restore it. The authors designate this loss of capacity as replaceable, and the expenditures involved in it as expenditures for replacement power.

Then we determine the adduced expenditures based on replacement power according to the formula:

$$З_{зк} = И_{пр} + E_н K_{зам} + И_{зам}, \qquad (1)$$

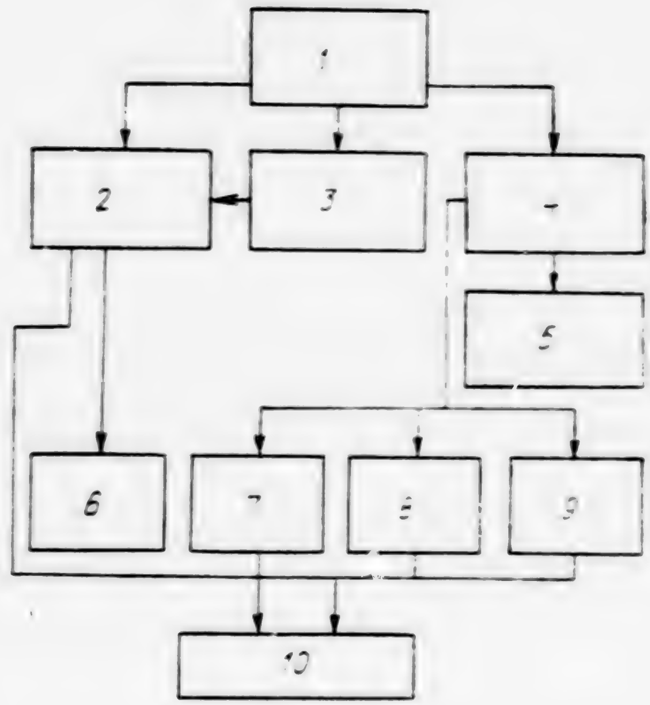
where $И_{пр}$ are the operating costs to generate an equivalent of the product (in our case, for 10 kW·hrs of electrical energy released); $E_н$ is the coefficient of efficiency of the capital investments; $K_{зам}$, $И_{зам}$ are the capital investments and operating costs, respectively, for the replacement power due to the energy equivalent.

If it is impossible to compensate for the r placeable power and if there is an underdistribution of electrical energy, this is a loss for the national economy. In this case the adduced expenditures include the operating costs of the electrical energy sector and the national economic losses $У_{нэ}$, the estimated magnitude of the underdistribution and the average relative amount of the loss for 1 kW·hr of underdistributed electrical energy

$$З_{нн} = И_{пр} + У_{нэ}, \qquad (2)$$

Therefore, the correct economic estimate of each of the directions can be obtained after the values of such indicators as the expenditures for the replacement power and the amount of the national economic loss, connected with a change in the fuel quality level, are made more precise.

An underdistribution of electrical energy resulting from a power shortage by individual coal-pulverizing units during the hours of maximum load forms a basic part of the replaceable power and national economic loss (sketch).



Structural Diagram of the Formation of Replacement Power With a Change in the Quality of the Fuel:

1--Lowering the quality of solid fuel as compared with the rated quality; 2--Power shortage (undergeneration of electrical energy); 3--Lowering the efficiency of the boiler units; 4--Increasing the fuel consumption; 5--Combined expenditures for fuel extraction and transport; 6--National economic loss due to restricting the consumption of electrical energy; 7--Additional consumption of electrical energy for industry's own needs; 8--Restricting the productivity of mechanisms for industry's own needs; 9--Increasing the length of time for repairs; 10--Replacement power.

The authors used information from the Southern ODU on 18 300-MW units and on 31 200 MW units, operating on solid fuel. Through mathematical data processing, the relationship between a change in the amount of underdistribution of electrical energy for reasons connected with an increase in the ash and moisture contents of fuel coal was obtained.

The indicators for the earlier-mentioned directions in function of a change in the ash content of fuel were calculated according to models of adduced expenditures [1, 2]. The direction without measures to change the quality of the fuel and the technology was taken as the base one. Expenditures for the

variant with enriched solid fuel, as well as with use of two-stage technology for processing fuel, including its gasification, were also calculated. The calculated full cost of 10 kW·hrs of electrical energy released, allowing for expenditures for replacement power and national economic loss of kop/10 kW· hrs is shown in Table 3.

Table 3

Indicators	Directions	Coal Grades	With working ash content of fuel, in % 20	30	40	50	60
Outlays for power (1)	Base	G.D.	9.55	14.90	17.91	18.58	16.51
		ASh	12.88	14.73	15.96	16.57	16.56
		T	10.38	13.58	15.34	15.66	14.54
		L-V	8.96	13.81	16.32	16.49	14.32
	With enrichment	G.D.	---	12.93	13.77	16.52	21.17
		ASh	---	11.46	14.57	17.54	20.37
		T	---	13.03	14.42	16.39	18.35
		L-V	13.32	13.47	14.84	17.43	21.24
	2d stage	G.D.	---	17.92	19.55	18.96	15.95
		ASh	---	16.34	18.67	17.18	11.87
		T	---	15.81	16.93	15.37	11.13
		L-V	---	15.58	18.43	16.58	10.03
Outlays for national economy (2)	Base	G.D.	11.98	18.53	24.98	31.43	37.58
		ASh	15.60	19.15	29.00	45.15	67.60
		T	13.92	19.22	31.20	49.86	75.20
		L-V	21.75	23.55	30.07	42.24	59.67
	With enrichment	G.D.	---	13.75	18.40	23.55	29.20
		ASh	---	13.76	21.63	28.72	35.03
		T	---	15.00	22.01	29.63	37.23
		L-V	---	17.40	24.67	31.98	39.07
	2d stage	G.D.	---	24.04	26.80	29.66	32.60
		ASh	---	21.36	29.60	35.08	37.80
		T	---	25.04	28.96	34.00	40.16
		L-V	---	24.74	34.34	41.34	45.74

The cost of fuel is calculated in accordance with the price list, allowing for the appropriate reductions and increases and the average transport rate for the UkSSR Ministry of Power and Electrification according to the grades of coal. Other expenditures were taken into account according to the data from calculating the cost of TES electrical energy and the UkSSR Ministry of Power and Electrification, allowing for their tendency to change in the last decade.

In accordance with the data in Table 3, the following conclusions may be drawn:

Enrichment of power-generating coals is most efficient with ash contents of run-of-mine coals from 25 to 50%, which makes it possible to save from 1.86 (for ASh) to 2.8 kop. (for G, D) per 10 kW·hrs of electrical energy released;

With ash contents of $A_p \geqslant 50\%$, a transition to a two-stage industrial process for processing solid fuel is economically substantiated.

According to the dynamic series series obtained by the authors for distributing the weight of power-generating coals by degrees of ash content and level of their extraction volumes, enrichments should be increased by a factor of 1.5.

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12151
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GOSKOMTRUD OFFICIAL DISCUSSES WAGE RATE CHANGES

Moscow AGITATOR in Russian No 5, Mar 87 pp 13-16

[Article by V. Shcherbakov, chief of the ussr Goskomtrud Wage Department, candidate of economic sciences: "Your Wage Rate"]

[Text] The wages of manual workers in our country, as can be seen from Table 1, have been growing steadily. Moreover, they have been increasing faster than for other groups of workers -- during the past three five-year plans, the earnings of all the workers and employees in the national economy increased on the average by 56 percent; in industry, by 62 percent; in construction, by 65 percent; and at state agricultural enterprises, by 82 percent. In the 12th Five-Year Plan a further growth has been planned and is already being carried out.

Table 1

Average Monthly Wages of Manual Workers, By Branches of the National Economy (rubles)

	1970	1975	1980	1985
Industry	130.6	160.9	185.5	211.7
Agriculture	98.5	124.7	148.5	179.7
Construction	148.5	180.3	207.9	245.3

The 27th Party Congress pointed out the need to intensify supervision over the measure of labor and consumption and to establish a stricter dependence of wages upon labor productivity and the qualitative indicators of labor. The task posed is to take decisive steps to eradicate an equalization policy, and to prevent the payment of unearned money and undeserved bonuses. "When the labor performed by a good worker and the labor performed by a careless worker are paid identically," the statement was made at the congress, "this is a crude violation of our principles. And this is primarily a distortion of the basic principle of socialism 'From each according to his capabilities, to each according to his labor,' which represents the essence of the social justice of the new social system."

Proceeding from the fundamental instructions, the CPSU Central Committee, USSR Council of Ministers, and AUCCTU adopted the decree entitled "Improving tne Organization of Wages and the Introduction of New Wage and Salary Rates For Workers in the Production Branches of the National Economy." In conformity with that decree, in the 12th Five-Year Plan new increased wage and salary rates will go into effect for 75 million workers and employees in industry, agriculture, construction, transportation, and communication.

The matter, however, cannot be summarized simply in this way. The foundations of the present system of paying for labor were formed as long ago as the mid-1950's and today do not conform properly to the tasks of changing over to intensive methods of management and of accelerating scientific-technical progress. We have seen in this area the accumulation of a large number of problems which now have received comprehensive resolution with a consideration of the practically tested, progressive forms of organizing, establishing norms for, and paying labor. The topic under discussion is assuring that wages actually become earned both by the production collective and by each individual worker, and assuring that they effectively promote the resolution of the priority tasks in the development of the national economy.

Let us consider specifically what has been changing in the payment of the workers' wages, why, and in what directions. First of all, the task posed is to return to the wage rate system its role as the chief state regulator of wages, and the basis of organizing wages at the enterprises. This role of that system has proven, to a considerable degree, to be lost, inasmuch as the wage rates, which for the most part remained unchanged for more than ten years, seriously lagged behind the overall size of the earnings, which had grown considerably during that period. The share of the rate in that overall size dropped on the average to 50-60 percent.

Correspondingly, there was an excessive increase in wages in the share of all kinds of additional payments, bonuses, and extra piece-work payments. Frequently they are computed, in addition, without any consideration of the worker's proficiency level, his working conditions, or the true effectiveness of his labor; they lose their incentive role, and are turned into a mechanical, previously stipulated addition to the low wage rate, into a mechanism for bringing the wages up to the level that has developed and that is rarely justified. Broad opportunities are revealed here for subjective decisions and crude violations of the principles of economic desirability and social justice.

Frequently wages are used as a means of attracting and permanently assigning cadres. Instead of resolving this problem by the technical improvement of production, with a corresponding rise in people's proficiency level, by the improvement of their working conditions, certain enterprises take the easier, but incorrect and harmful path of obviously overstating the wages by using understated individual-output norms, by the payment of additional wages and bonuses which, essentially speaking, are not earned and which are not linked with the results of labor.

In order to eliminate these negative phenomena, it has been planned to raise the wage rates on the average by 20-25 percent. As a result, the share of the rate in the earnings will increase to 70-75 percent, and this will restore the workers' proficiency level and the complexity of his labor as the primary role in determining the size of the earnings.

But we by no means have in mind the equal increasing of all the wage rates. On the contrary, their differentiation in the course of the overall growth will increase. The fact of the matter is that the centralized increases in rate which were carried out during previous years basically affected the workers receiving low wages. As a result an abnormal situation developed, in which, in a number of branches, the wage rate for the highest category, Category 6, was only 1.5 times greater than for a newcomer in Category 1. In addition, as can be seen from Table 2, the share of the workers in the lowest category itself became quite insignificant in industry. In other words, there was a smoothing out of the differences in the payment of complicated and simple labor.

Table 2

Distribution of the Number of Industrial Workers With Wage Rates in the 6-Category Wage Rate System, By Categories, as of 1 August 1985 (in percentages; average category 3.61)

Category	Percent
1	4.1
2	16.8
3	27.9
4	24.1
5	19.0
6	8.1
	100.0

This lowered the workers' self-interest in raising their proficiency level and in mastering complicated, responsible operations, at a time when their share, as a result of technical progress, has been increasing. At a number of enterprises, difficulties have been arising in the manning of subdivisions that are engaged in the repairing and adjustment of equipment, and in experimental and cutting-tool production. Frequently there is a shortage of highly qualified machine-tool operators. All this has had a detrimental effect upon the work load placed on the equipment and the intensity of its use, and has been slowing down the technical re-equipping of the enterprises and the assimilation of new technology, technological schemes, and output.

The present measures have been called upon to eliminate the elements of a policy of equalization in payment and to restore the authority and prestige level of complicated, skilled labor. The increases in the wage rates for the

higher categories are planned to be much greater than those for the lower ones. For example, in the food industry the wage rate in Category 1 is increasing by 16 percent, and Category 6 by 33 percent. In light industry, the increases are, respectively, 18-19 and 24-25 percent; and in machine building, 19-20 and 26-27 percent. As a result, while the 6-category wage rate schedule is retained in most branches, its range (the ratio of the highest rate to the lowest) increases to no less than 1.8, as compared with less than 1.6 at the present time.

In light industry the greatest increase in rates will occur for skilled workers, in Categories 4 through 6, in the garment and knitwear industry; in the food industry, for persons employed in the breadbaking, sugar, and meat-processing subbranches. As a whole, the wage rates of skilled workers in the light and food industry approach, from the point of view of their size, the corresponding rates in the processing branches of heavy industry.

In energy engineering, higher wage rates (8-10 percent higher than at thermal-electric power plants) have been established for workers at nuclear power plants. For persons engaged in servicing especially complicated and powerful turbines, noncategory rates of 220 and 240 rubles have been established. In metallurgy, increased rates have been provided for highly skilled workers who service powerful, complicated, and unique equipment in basic production, as well as highly productive technology in quarries. In transportation the wage rates that will rise to the greatest extent are those for engineers of high-speed heavy and extra-long trains, and drivers of highly productive motor vehicles and those that use trailers. The rates for persons engaged in loading and unloading operations will be raised substantially.

Especially major changes have been planned in paying for the labor performed by machine builders. Three wage-rate levels are being introduced for them. The highest is for cutting-tool workers, repair men, and adjusters who service automatic lines, machine tools with digital programmed control, flexible production systems, and other complicated highly effective equipment. Their rates, as compared with the ones that are currently in effect, will rise by 40-45 percent, and for this group of occupations, for the first time, instead of a 6-category wage rate schedule, an 8-category one is being introduced, with the rates in Category 8 being double those in Category 1. A second, somewhat lower, level of wage rates is established for persons engaged in operations on metal-working machine-tools, the cold stamping of metal, and the repair of cutting tools and equipment. And the third level is for all other workers in the branch. With identical categories, the wage rates for these levels have a ratio of 1.21 : 1.08 : 1.

Thus, the occupations and specialties that are put in a preferential position are those that determine the rates of technical progress in production. It will be necessary to carry out anew the establishment of rates for operations and the qualification categories of workers in conformity with the new wage-rate and qualification reference books. The majority of people will continue to have the present categories, but wherever the technology, technological processes, or organization of labor has changed, and wherever there had previously been violations in the establishment of wage rates, the categories will have to be reconsidered. It has also been established that, in the event

of crude violations of technological discipline, the wage-rate category of the person to blame can be reduced for a period of up to three months, and in order for his previous category to be reinstated it is necessary to confirm his qualification level.

The system of pay differentials added onto the wage rates for mastery of one's occupation is being retained. It is authorized to establish them for workers in Category 3 in the amount of up to 12 percent of the wage rate; Category 4, 16 percent; Category 5, 20 percent; and Category 6, in the amount of up to 24 percent of the wage rate. These differentials are no longer linked with work longevity. In order to receive them, it is necessary to guarantee steadily the high quality of operations being carried out and of the output being produced. During the months when the worker produces defective output or allows that quality to drop, the differential is not paid to him, and if he regularly produces inferior output or fail to fulfill the production assignments the differential is completely canceled.

A fundamentally new procedure is going into effect for compensating for unfavorable working conditions. Until the present time, as everyone knows, increased wage rates were employed for persons engaged in heavy operations or in operations having hazardous working conditions. They were used for entire occupations in accordance with a list of them that had been approved in a centralized manner, irrespective of the real conditions at the specific work stations or the time that the person was actually engaged in operations under unfavorable conditions during the course of his shift. This depersonalization and averaging led to a situation in which some workers received unjustifiably increased payment, and others received unjustifiably reduced payment. In a number of instances it was becoming difficult to attract people to work stations that were actually unfavorable with regard to the working conditions.

Now the working conditions are taken into consideration in the rates themselves only in the coal industry, metallurgy, and chemistry. But in all other branches the enterprise managers have been granted the right to introduce, after coordinating this with the trade-union committees, additional payments in the amount of up to 12 percent of the wage rate for operations with heavy and hazardous working conditions, and up to 24 percent for operations with especially heavy and hazardous conditions. In addition, the right to receive the additional payment does not arise automatically, depending upon the occupation, but on the basis of the results of an evaluation of the actual state of the working conditions at the specific work stations on the basis of their certification. The list of such work stations and the size of those additional payments are included in the collective contracts simultaneously with the measures to improve the working conditions. When these measures are carried out, the additional payments can be reduced or even canceled. In this instance the previous level of earnings can be preserved on the basis of an increase in labor productivity or the improvement of the qualitative indicators of labor.

The taking into account of labor intensity in paying for labor has been improved somewhat. In this regard also a rather large number of problems have accumulated, and in a number of instances the size of the earnings is poorly linked with the actual work load during the course of the shift. For example,

for a drill operator, stamp operator, or person employed on a conveyor belt, the share of active labor is as much as 70 or even 90 percent of his time, but for a planing machine operator or, say, equipment operator, that share does not exceed 50 or even 30 percent. And yet their wage rate is frequently identical.

At the present time the enterprise managers in machine building and light industry are authorized, after coordination with the trade-union committee, to establish additional payments for increased labor intensity on conveyor, flow, and automatic lines in the amount of up to 12 percent of the wage rate. The specific sizes are determined on the basis of the results of work-station certification and in the total amount including the additional payment for working conditions are limited to 24 percent of the wage rate. In addition to that, it is authorized to increase the piecework rates as much as 20 percent when using branch, interbranch, and other progressive norms.

In development of the well-known Shchekin method, the enterprises have been granted broad rights in providing incentives for fulfilling the planned assignments with a smaller number of personnel. The wage economy that has been formed as a result now remains completely at the disposal of the shop or sector and is distributed among the persons who have assumed the additional work load. If, for example, three people, by combining their occupations or expanding their service zones, fulfill on an equal basis the duties of four people, each of them gets one-third of the earnings that would have gone to the fourth person. But if a person who is no longer on the job for a particular reason can be qualitatively replaced by another person, and if is irreproachably coping with the double work load, then it is as though he can receive two wages. Of course, when substantiating the norms, one can scarcely expect that this situation can be widespread, but in principle even this is authorized. Thus, more favorable conditions are created for people to display their creative capabilities, and for mobilizing the reserves for increasing their labor contribution and introducing advanced experience.

The new incentive system that went into effect on 1 January 1987 also acts in the same direction. The essence of this system lies primarily in the fact that the enterprises are granted the right by themselves to develop and approve statutes governing the providing of incentives, proceeding from the specific production conditions and tasks to be performed by the subdivisions. Obviously, in any instance these statutes must be such that the bonuses effectively encourage the plan fulfillment, the hundred-percent observance of the contract pledges, the increase in labor productivity and improvement in the quality of output, the reduction of production costs, and the achievement of high final results of production activity. The incentive terms must be simple and easily understood by every worker.

Provision has also been made for changeover from the paying of individual bonuses to the paying of collective ones. At such time, on the average, for the collective of the brigade, sector or shop the maximum size of the monthly bonus paid to the workers, as has been the situation up to now, is limited to 40 percent of the total amount of their wage rates. But within the confines of the total amount computed for the collective, the maximum sizes of the bonus paid to individual workers are not limited now. A person who has made a

major contribution to the overall success can receive as much as the collective itself determines. At the same time those who are guilty of reducing the quality of the output, of violating technological discipline, of causing claims to be made, of nonfulfillment of the contract pledges, or other omissions must not and will not receive any bonuses at all. It is necessary here to observe strictly the principle of social justice: to each according to his labor, according to his real merits.

In by no means all enterprises are these principles being followed. In a few places the approach taken to working out the conditions for the payment of bonuses have been a formal one, without the consideration of today's requirements, and administrators continue to be guided by obsolete rules and traditions and to orient themselves chiefly to paying bonuses for the achievement of quantitative indicators and according to the principle "to all the sisters according to their earrings" [vsem sestram po sergam]. This is completely inadmissible.

The new payment conditions must be made completely known to all the enterprise workers. Any worker must have a clear idea of how his earnings are determined, what specifically is required of him in order to have a higher wage rate, an additional payment added to it, and substantial bonuses, and how he must fulfill his duties in order to earn more without any figure-padding or misrepresentation of the true situation, without any self-seeking or hack work, but only by his honest labor. Naturally, much can and must be done here by the activists in verbal and graphic political agitation. Another task of theirs consists in helping to mobilize the collective for the most rapid creation of the conditions for introducing the new wage rates and the new payment conditions in general.

The fact of the matter is that, unlike the situation that used to prevail, the raising of wage and salary rates in the production branches now will not be financed from the state budget. The funds that are necessary for this purpose must be earned independently by the enterprises, that is, the enterprises must, in the practical situation, implement the principles of payment of one's own way, or self-financing, which are to be introduced into the economic mechanism. The enterprises have been given firm guarantees that they will continue to have at their disposal the entire saving in the wage fund, as compared with firm norms for its formation which have been established for individual years of the five-year plan, and that they will be able to channel all this saving into the introduction of the new conditions for payment of labor. But the saving must be obtained, and for that purpose the production collectives must substantially improve their economic activity.

The funds can be earned primarily by increasing the labor productivity, by increasing the production of high-quality output with the previous or even small number of personnel. For this purpose it is necessary to accelerate the introduction of advanced technology and progressive technological schemes, to improve the organization of labor and production, to introduce more broadly cost accounting and the contract at the shop, sector, and brigade level, and to show more boldness in rejecting unmandatory work stations, and especially those that are obviously surplus. At a number of enterprises a major saving of funds can also guaranteed by introducing elementary order into the

establishment of norms for labor and into the payment of labor, by eliminating the understated norms for individual output and all kinds of overstated additional payments, pay differentials, and bonuses that, essentially speaking, have not been earned by the people.

As the funds are accumulated, the new wage and salary rates can be introduced either immediately for the entire collective, or for individual structural subdivisions or categories of workers (in this instance the raising of the salary rates of administrators and workers in the administrative apparatus is to be done last of all). During the period of introduction of the new wage rates, as, incidentally, has always been the case, provision must be guaranteed for the outstripping increase in labor productivity as compared with the increase in wages. This is an absolutely mandatory condition for reinforcing the monetary circulation and for balancing the monetary income with the supplying of commodities and services.

A determination has been made in a centralized procedure only for the final deadline for changing over to the new conditions for payment of labor -- 1990. But each enterprise must make its own determination about the specific deadlines. Many enterprises have undertaken the task of locating by funds necessary for that purpose by 1987. Everything here depends upon the initiative, energetic nature, and rate of participation of every worker, upon the effectiveness of the socialist competition and scientific-technical creativity, and upon the level of mass political work in the collective.

5075
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LEGISLATION ON PRIVATE LABOR ACTIVITY NOTED

Editorial on Scope

Moscow IZVESTIYA in Russian 23 Mar 87 p 1

[Unattributed article: "Until the First Patent Is Issued"]

[Text] Nowadays the following situation is a completely real one: a citizen arrives at the ispolkom of the local Soviet and says that he would like to engage in private labor activity but does not know where to begin. There is the danger that such a visitor will go from desk to desk and from one floor to another before he hears something like the following: "You've arrived a bit too early; not everything is clear for us either. You see, we don't even know who will handle this section of work. But, after all, the law on the matter of concern to you will not take effect until 1 May. There is still time...."

Alas, for those who think that way, there is almost no time left. This is in Moscow, where a commission on private labor activity has been formed and is functioning under the ispolkom; there is indeed still time to determine the most important lines of such work for the city and its citizens, to carry out an inventory of non-residential quarters, to free up and renovate at least a portion of them, and to concern themselves with the reserve supply of materials and tools. All this work is coordinated, if one may put it that way, by Mosgorispolkom's Central Commission, whose plans were recently Talked about in IZVESTIYA within one of the traditional "Commercial Surveys."

There is time for the Commission of the Presidium of the Supreme Soviet of Latvia to sum up the preliminary results of numerous experiments. The commission has been operating since last December, and during that time the number of citizens engaging in private work activity has almost doubled in the republic. Of particular interest is the experiment of using personal transport as taxis and that of various cooperatives operating by contracts with enterprises or completely independently. And there is yet another experiment that merits the professional attention of local Soviets: under the Riga Gorispolkom a special division has been created, composed of specialists on whom, to one degree or another, the private labor activity of the population depends.

In Estonia experiments are being conducted in a field which is traditional for private labor--public dining--and in lines where it is still uncommon--making tiles and show windows, massage procedures, etc. Active preparations are being made to implement the Law on Private Labor Activity in the cities and settlements of Belorussia, Moldavia, as well as in Moscow Oblast and certain other oblasts.

In many places, however, they are still waiting. If it's official, they are waiting for normative documents, statutes, and written instructions. If its unofficial, they are obviously waiting until the situation clears up. Perhaps this private labor activity is not such a serious thing. Some noise will be made, and then it will be forgotten. Or everything will take shape by itself: if you want to engage in private work, set yourself up as best you can, and we won't even provide any personnel unit for you.

All this, of course, is from the realm of conjecture, because actually something else is said: give us methodological documents! A justifiable requirement. The USSR State Committee for Labor and Social Problems, the USSR Ministry of Finance, and the sectorial ministries concerned could have responded to this requirement somewhat earlier. But, one way or another, the work of preparing normative acts was recently concluded. Proposals were introduced into the government with regard to taxing private labor activity, paying out established pensions for it, and granting credits to obtain raw materials, equipment, and tools. Recommendations have been approved with regard to applying certain statutes of the law. For example, on the private labor activities of physicians or the owners of motor vehicles.

Each of these documents certainly merits individual, detailed discussion--with figures and breakdowns. But for now, let's confine ourselves to the central idea which the developers of the normative acts were guided by: a minimum of limitations and regulations; no document or condition must hinder but rather must assist private labor activity.

Many of these documents have obviously already been received by the ispolkoms. And if they read them, they were convinced that they waited inactively in vain. Because, even without specific instructions they could have and should have determined which types of activity were particularly important in the region, what requires a solution or a patent and what was completely permissable without have to fill out official forms, what enterprises could conclude contracts, how and where to market cottage-industry products, and a great deal else.

At a recent conference in the Presidium of the USSR Supreme Soviet devoted to the upcoming introduction of the Law on Private Labor Activity it was noted with concern and alarm that such work has been begun only in places. And alarm not just because there is very little time left but also because the very attitude toward private labor activity is changing too slowly. Some people are inclined to see in this law a temporary concession; yet it is not very clear precisely to what.

The departments called upon to provide favorable conditions for private labor are not preparing very actively to implement the law. It seems as though

something is being done by USSR Gossnab, the USSR Ministry of Trade, the USSR Ministry of Health, and other ministries, but if one is interested in specific figures.... How many, for example, and what kinds of materials and tools could Gossnab allocate? How will the Ministry of Trade help in marketing products? What kinds of relations will there be between persons engaging in private labor and the Central Trade Union?

Scarcely more than a month remains before the implementation of the Law on Private Labor Activity, and, as we see, there are still quite a few problems and unresolved questions. And probably the biggest problem is seeing to it that persons interested in engaging in private labor activity manifest a genuine interest and organizational capabilities. People who desire to engage in private labor activity will facilitate the solution of a state problem of great social significance. In and by itself, this is a sufficiently complex matter, and there is no sense complicating it artificially.

Financial Aspects

Moscow IZVESTIYA in Russian 21 Mar 87 p4

[Interview with V. Tur, deputy chief, State Revenues Administration, USSR Ministry of Finance, by IZVESTIYA correspondent V. Borisov: "Payment for a Patent"; date and place not specified; first paragraph is source introduction]

[Text] The USSR Ministry of Finance has determined the tax payment method for those citizens who, subsequent to the 1st of May, will be starting to pay in accordance with the law on private labor activity. Our correspondent discusses this with deputy chief of the State Revenues Administration, USSR Ministry of Finance, V. Tur.

[Question] Where should a person turn who has decided to engage in private labor activity in order to obtain a patent?

[Answer] First of all, it is necessary to submit a written application to the ispolkom of the local Soviet of People's Deputies. Its examination will be conducted by a commission which must include representatives of various sectors of the city administration, organs of labor, justice, law and order, and finance. Each application will be studied, and only after the ispolkom of the local Soviet adopts a positive decision do the finance organs issue a registration certificate or a patent. It should be taken into account that the legislation of the Union republics and the ispolkoms of the local Soviets can permit certain types of private labor without filling out any particular documents, on condition, of course, that they do not go beyond the framework of what is permitted by the Law. These are one-time services during the course of a year and work which is not typical of a widespread industry, when the total of the income received does not exceed the minimum monthly wages of workers and office employees, i.e., 70 rubles. As to the sale of pictures, sculptures, and items of applied art, here the decision will be taken by an arts council functioning under the local Soviet, or under ministries and departments.

Acquiring the right to engage in private labor activity imposes certain obligations. In particular, a private artisan must keep accounts of his income, submit a declaration concerning its amount, and pay his income tax in full. The correctness of its payment is monitored by the state. But such scrupulous controls are not always possible. Therefore, the issuance of patents for which a pre-payment is levied will be widely practiced. This is essentially the same as an income tax but is paid in advance. The right to approve the amounts of the annual payment has been granted to the Councils of Ministers of the Union republics. In determining them, it has been decided to rely on the evolved annual income of citizens and on the earnings of employees engaged in analogous work in the sphere of the public economy.

[Question] How much will be necessary to pay for a patent if the individual employee would like to engage in his own work not for an entire year but only part of it?

[Answer] In such cases the amount of the payment must be calculated taking into account the full number of months during which the holder of the patent is permitted to engage in private labor. There must not be any errors here. The Law provides that the employee himself must monitor all his revenues and expenditures. A special book for keeping their accounts has been developed. It will be available in the local financial organs. It will help them to correctly compile a declaration of their incomes for presentation to the finance organs.

[Question] What is the procedure for submitting a declaration of income?

If a master artisan begins engaging in private labor for the first time, he will submit a declaration within a month after beginning work. On a special form all the income received during this period will be calculated. This data will allow the finance organ to determine the annual income and the amount of the income tax. According to the year's results, the declaration is already filled out on the actual income. Going by this, the finance organ determines the final amount of the tax, appropriately decreasing or increasing it. It should be noted tnat, in this conection, the finance organs for themselves retain the right to verify the exactness of the of the delarations submitted. Concealing income is punished in accordance with the Law. Nor is artificially puffing up the tax permitted.

[Question] Many persons are bothered by the following question: will the tax policy lead to a situation whereby it will become unprofitable to engage in private labor activity?

[Answer] The amounts of the taxes are established depending on the total income received and taking social interests into account--that's what the Law proclaims. It is precisely this principle that constitutes the foundation of the new tax system in the field of private labor activity. Beginning on 1 May, individual artisans will pay taxes at lower rates. If his annual tax does not exceed 3,000 rubles (an average of 250 rubles a month), the tax will be the same as that of workers and office employees in the national economy. If the

income exceeds 3,000 rubles a year, the tax will be increased, but not in such amounts as provided for by the presently existing legislation. And only in case the earnings exceed 6,000 rubles a year will the tax be levied at the maximim rate, in an amount exceeding half of the income.

On the whole, this will ensure the motivation of citizens and will correspond to the principle of social justice.

2384
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FINANCIAL EXPERT ANALYZES PRODUCTIVITY, WAGE CORRELATION

Moscow FINANSY SSSR in Russian No 2, Feb 87 pp 37-41

[Article by K. A. Strelkova, chief expert, Finances and Money Circulation Administration, USSR Ministry of Finance: "Equal Pay for Equal Work"]

[Text] The 12th Five-Year Plan's great objectives of increasing production and public welfare will become reality only on the condition that every Soviet citizen works hard and effectively. Wages--the principal component of income--must be made commensurate with work results.

The principles of the wage system presently operating in the national economy were formed in the mid-1950s, in a period of wage reorganization; today they no longer satisfy the greater requirements of modern times. The objective in those years was to reduce the gap between the wages of low, middle and high income categories of workers. As a result the gap between the pay rates of workers in the highest and lowest categories in the principal sectors of industry was decreased by a factor varying from 2.5-3.5 to 1.8-2. The ratio between the wages of laborers on one hand and engineers and technicians on the other was 1:1.5.

Since that time the minimum wage has been raised several times, and new pay rates and salaries were introduced into the sectors of the national economy twice. Thus in 1973-1975 new pay regulations were introduced simultaneously with raising the minimum wage (to 70 rubles per month). This affected 55 million blue and white collar workers of the national economy's productive sectors. The wages and salaries of 7 million physicians, teachers, educators and some other categories of workers were increased in the 9th Five-Year Plan. The pay rates and salaries of 31 million workers in the nonproductive sphere were increased in 1976-1979. In the 10th Five-Year Plan the wages of certain categories of workers in important sectors of the national economy such as ferrous and nonferrous metallurgy, coal and textile industry, construction, agriculture and rail transportation were increased centrally. An increase in the minimum wage (to 80 rubles) and in the pay rates and salaries of blue and white collar workers chiefly in the productive sectors of the national economy was proposed in the 11th Five-Year Plan. As a result of the centralized measures, the wages of over 20 million persons, including many rural laborers, were increased in 1981-1985. Bonuses for length of service were introduced into rail transportation, into contracting construction organizations and into

some other sectors. The wages of blue and white collar workers of coal industry increased.

Measures to increase minimum pay and to introduce new, higher pay rates and salaries were funded practically completely by assets from the state budget. The level and dynamics of the mean montnly wages of blue and white collar workers are characterized by the data in the table below:

Indicator	1965	1970	1975	1980	1985
Mean monthly wages of blue and white collar workers including one-time bonuses), rubles	96.5	122	145.8	168.9	190.1
Five-year increment: Rubles	8.8	25.5	23.8	23.1	21.2
Percent		26.4	19.5	15.8	12.5

Consequently in 1965-1985 tne mean monthly pay of blue and white collar workers increased as a whole by a factor of 1.7. A higher growth rate and greater absolute increments are typical of wages when payments and benefits provided by social consumption funds are accounted for:

Indicator	1965	1970	1975	1980	1985 (Calculated)
Mean monthly wages of blue and white collar workers with regard for social consumption funds, rubles	129.2	164.5	198.9	232.8	272.4
Five-year increment: Rubles		35.3	34.4	33.9	39.6
Percent		27.3	20.9	17.0	17.0

Thus taking account of social consumption funds, in 20 years the mean montnly wages of blue and white collar workers more than doubled, and the absolute increment of wages exceeded the increment in mean monthly wages disregarding social consumption funds by almost three times. Measures to raise the minimum wage in the 1970s were implemented in the face of a certain increase in the differences between the wages of low and moderate income workers. This can be explained by tne fact that in 1970 the average wages of blue and white collar workers exceeded the minimum level by a factor of 2, and further reduction of the difference between these wages could have weakened the work stimuli enjoyed by moderate income workers. In this connection while the wages of

blue and white collar workers grew by 38 percent in 1971-1980, the minimum wage was raised by 17 percent. As a result in 1975 the average wages of blue and white collar workers exceeded the minimum level by a factor of 2.1, while in 1980 the minimum was exceeded by a factor of 2.4.

However, growth of the wages of blue and white collar workers was not always followed by the same growth in labor productivity. Wages grew faster than labor productivity in construction and agriculture, in enterprises of the USSR Ministry of Petroleum Refining and Petrochemical Industry, the Ministry of Chemical Industry, the Ministry of Electrical Equipment Industry, the Ministry of Tractor and Agricultural Machine Building and the USSR Ministry of Construction Materials Industry, and especially at enterprises of the USSR Ministry of Meat and Dairy Industry and the USSR Ministry of Light Industry. Wages increased in the USSR Ministry of Ferrous Metallurgy, the USSR Ministry of Nonferrous Metallurgy and the USSR Ministry of Coal Industry despite a drop in labor productivity. This naturally had an effect on the balance of the economy, money circulation, the purchasing power of the ruble and the material interest of the workers.

Not all has been done yet in industry to reduce labor characterized by low productivity. In the last 10 years the proportion of manual workers decreased annually by an average of only 0.7-0.8 points on the average. To retain people in low-skilled and manual jobs the enterprises sometimes inflate the wages, apply obsolete norms and standards and increase the rates and dimensions of bonuses. The ratio between the pay levels of engineers and technicians and the pay of laborers in industry and construction has worsened (Table 1).

Table 1. Ratio of the Wages of Engineers and Technicians and of White Collar Workers to the Wages of Blue Collar Workers (in Different Years, Percent)

Year	Industry		Construction	
	Engineers, Technicians	White Collar Workers	Engineers, Technicians	White Collar Workers
1940	215	111	242	147
1960	151	82	157	101
1965	146	84	148	94
1970	136	85	135	92
1975	124	82	115	81
1980	115	79	102	71
1981	113	78	100	70
1982	112	77	99	69
1983	110	76	98	68
1984	111	77	98	69
1985	110	78	99	68

As a rule the average wages of engineers, technicians and white collar workers is below that of blue collar workers in machine tool building, chemical and
Table 2. Ratio of the Wages of Engineers and Technicians and of White Collar Workers to the Wages of Blue Collar Workers (in Different Ministries, Percent)

Union Ministries	1975 Engineers, Technicians	1975 White Collar Workers	1985 Engineers, Technicians	1985 White Collar Workers
Ministry of Heavy and Transport Machine Building	102	68	95	67
Ministry of Power Machine Building	97	66	97	71
Ministry of Chemical and Petroleum Machine Building	102	72	98	76
Ministry of Machine Tool and Tool Building Industry	99	72	96	75
Ministry of Machine Building for Animal Husbandry and Fodder Production	105	76	89	69
Ministry of Construction, Road and Municipal Machine Building	103	75	93	73
Ministry of Machine Building for Light and Food Industry and Household Appliances	98	74	90	74

petroleum machine building, construction, road and municipal machine building, machine building for light and food industry and household appliances, and in machine building for animal husbandry and fodder production (Table 2).

For practical purposes the wage level today does not depend on production effectiveness (products may be either good or bad); therefore the wage system and its application practice require improvement. We need to organize the use of assets for payment of bonuses to labor collectives and laborers for successes in accelerating scientific-technical progress, and we need to introduce the latest accomplishments faster. The material incentive system is very cumbersome and ineffective: Dozens of different forms of stimulation are now in use. Bonuses are often paid to all, irrespective of the end results or the personal contribution of the individual worker.

As was noted in the 27th CPSU Congress, the increase in the pay and salaries of blue and white collar workers in productive sectors will be increased for the first time in the 12th Five-Year Plan mainly on the basis of assets earned by the enterprises themselves, and within the limits of these assets, which will make it possible to promote acceleration of technical progress and growth of production effectiveness more actively. The new approach to resolving the issue of raising wages was tested out experimentally on the Belorussian Railroad, where all of the needed assets were obtained from internal sources as a result of extensive economic and organizational preparations and better use of equipment.

The system of measures to organize wages that was approved in September 1986 is closely associated with measures to improve the economic mechanism. First of all, the proportion of pay in wages is to be increased to 70-75 percent (as opposed to the present 50-65 percent) by increasing the pay rates of workers by an average of 20-25 percent in the different sectors and the salaries of executives, specialists and white collar workers by an average of 30-35 percent.

Increases in the pay rates and salaries will also require growth of labor productivity and an increase in wages. They cannot remain unchanged for a long time while wages grow, inasmuch as this would not ensure the needed ratio of the wages of different categories of workers. Only piece-workers can increase their wages by increasing the amount by which norms are surpassed. This is explained to a certain degree by imperfections in labor standardization. Today, the average percentage of output norm fulfillment is 125.3 in industry and 137.2 in construction. Therefore the growth rate of the wages of piece-workers is many times greater than the growth rate of the wages of time-workers as well as those of engineers, technicians and white collar workers. This situation can be corrected only by improving pay rates and fundamentally changing their standardization. Associations and enterprises have been granted the right to review existing labor norms and standards no matter what their dimensions, as long as growth in labor productivity surpasses growth of wages.

There are plans for achieving higher growth of pay rates and salaries in those sectors of the national economy which are responsible for technical progress--nuclear power engineering, ferrous and nonferrous metallurgy, and machine building. As an example because of the key role played by machine building in reequipment of production, pay rates in machine building are being increased to 45 percent for laborers employed in the adjustment, repair and maintenance of especially complex equipment, and the ratio between the lowest and highest pay rates is changing. Concurrently to stimulate growth of qualifications and occupational proficiency more, an eight-level pay scale is being introduced in place of the existing six-level scale for this category of workers.

The pay rates of workers with high qualifications in light and food industry have been increased significantly. They are coming closer to the pay rates in processing sectors of heavy industry. The pay rates of construction workers have been increased by considerable amounts. The wages of skilled workers have been increased. The ratio between the lowest and highest pay rates has been changed to promote upgrading and fulfillment of harder jobs.

The pay rates set for piece-work are higher than those set for time-work in almost all sectors.

This situation can be explained by the fact that piece-workers make an effort to fulfill and surpass their output norms, they eliminate losses of work time and they work with greater intensity than time-workers. By setting higher pay rates for piece-workers, the state compensates for the higher intensity of the work of laborers.

Great changes are being made in the pay rates of engineers, technicians and white collar workers. First of all the ratio between the pay rates of laborers and the salaries of engineers and technicians is being improved. In general the salaries of the latter are increasing 10-15 percent more than the pay rates of laborers. The relationship between these categories of workers can be discerned especially clearly in the salary of the foreman, which has been established as a certain ratio of the pay rates of laborers. The salary policy of all other engineers and technicians is formulated on the basis of the foreman's salary. In turn, the foreman's salary is established depending

on the pay rates of laborers subordinated to him. The ratios between the salaries of foremen and the pay rates of laborers have been determined with regard for the unique features of different production sectors. Salary systems are set up such that a foreman's salary is either equal to the pay rate of the most qualified worker, or (in most sectors) higher.

The wages of specialists involved in the development of new equipment and procedures have been set higher (by 40-45 percent) than the wages of other specialists. The salaries of chief designers, chief process engineers, chief mechanics and the chiefs of production-technical departments exceed the salaries of the departments of labor and wages, economic planning and so on. To intensify the interest of engineers and technicians in upgrading themselves and the quality of their labor, four qualification categories are being introduced: engineer, category two engineer, category one engineer and chief engineer. These categories replace the presently existing positions of engineer and senior engineer. Class ratings are being established for foremen as well.

The range between minimum and maximum salaries is being increased significantly. The salaries of subdivision directors, specialists and white collar workers are set without compliance with the average salaries determined by the official schedule, and without regard for the relative numbers of specialists with different qualifications. Changes are also being made in the system of indicators used to classify enterprises in different executive wage groups. The number of personnel is being excluded from among these indicators, and simultaneously an orientation on raising the technical level of production and product quality is being encouraged. Savings enjoyed in the wage fund as a result of reducing the number of personnel, improving the wage structure and reviewing output norms and other labor norms, the bonus systems, raises and additional payments should become the chief source of assets to support new pay rates and salaries at associations and enterprises that make an effort to mobilize their internal reserves. In some cases part of the assets of the material incentive fund can also be used for this purpose, with the consent of the labor collective.

The new pay rates and salaries may be introduced simultaneously in the association or enterprise as a whole, or in its individual structural subdivisions, or in relation to specific categories of workers and occupations as the necessary assets are accumulated. In all cases, however, the salaries of administrative workers will be increased last (after the pay rates and salaries of other workers are increased). This affects the interests of 75 million of the country's blue and white collar workers. The growth rate of labor productivity must be kept higher than growth of wages in the period during which the new pay rates and salaries are introduced.

In order to raise the requirements on the work quality of executives, specialists and white collar workers and their responsibility for their work, these categories of workers will undergo certification. The association or enterprise management can use the results of this certification process to decide on moving the individual to a higher or lower position, awarding class ratings and qualification categories to workers, raising or lowering their salaries within the limits of the maximum or minimum salaries, changing or

repealing payments in addition to salaries and, in the necessary cases, firing personnel. The responsibility of association, enterprise and organization executives is also being increased simultaneously. If annual plans and assignments are left unfulfilled systematically, if equipment is used poorly and if product quality is low, ministers and department executives have the right to lower the established salary group, thus reducing the salaries of the executives of such enterprises and of their production subdivisions by up to 20 percent.

In order to increase the independence of associations and enterprises in appraising working conditions, their executives are granted the right to introduce additional payments to workers totaling up to 12 percent of the pay rate (salary) for jobs involving hard and harmful conditions, and up to 24 percent in relation to jobs involving especially hard and especially harmful working conditions, with the consent of the trade union committees. In sections, shops and production operations where more than half of the workers receive additional pay for harmful working conditions, similar additional payments are established for foremen, shop and section chiefs and other specialists and white collar workers who are permanently employed (for not less than 50 percent of the work time) in the given structural subdivisions. Additional payments for poor working conditions cost the state dearly, and therefore the effort to reduce the volume of such jobs must be accelerated.

The relationship between wages paid on the basis of the pay rate and the difficulty of the labor norms is being reinforced by establishing additional pay equal to up to 12 percent of the pay rates (salaries) of workers employed at conveyer, flow and automated lines.

In this case the total additional pay received as compensation for working conditions and for high work intensity must not exceed 24 percent of the pay rate. Such additional pay is included in the pay rates in relation to all calculations associated with wages.

The procedures for stimulating growth of the occupational proficiency of workers are being extended to all productive sectors (bonuses are being established totaling up to 12 percent for category III workers, up to 16 percent for category IV, up to 20 percent for category V and up to 24 percent of the corresponding pay rate for category VI and higher). However, such incentives cannot be paid in a month in which waste or a reduction of product quality is revealed, and when production of low quality products occurs systematically, they are repealed altogether. In addition the qualification ratings (classes and categories) of workers can now be reduced for gross violation of production discipline as well as for other serious violations that worsen the quality of the products they manufacture or the jobs they carry out.

The positive practice of paying bonuses during the period that it takes to carry out especially important jobs, established for scientists, designers, process engineers, foremen and shop executives, has made it possible to extend this bonus payment procedure to all specialists, white collar workers and executives (except directors) in productive sectors, in place of the bonuses presently being paid for high qualifications. The dimensions of these bonuses

will remain the same--up to 50 percent of the worker's salary, to be paid out of the wage fund, and within the limits of wage fund savings. In construction, bonuses for high accomplishments in labor are foreseen in accordance with the established procedure.

Great changes have been made in the organization of bonus payments with the purpose of ensuring a direct relationship between the labor of each worker and its results. There are plans for switching from individual payment of bonuses to laborers, specialists and white collar workers to awarding bonuses to the collective of the brigade, section, shop, department or some other structural subdivision as a rule.

Bonuses paid to workers out of the total bonus are determined by the collective itself depending on their personal contribution to the overall work results, and there is no maximum limit.

Executives of associations, enterprises and organizations have been granted the following rights, to be exercised with the consent of the trade union committee: to independently approve statutes on payment of bonuses to laborers, specialists and white collar workers in all structural subdivisions for the principal and other important results of economic activity, with regard for the specific tasks facing the labor collectives; to combine all assets held by special bonus payment systems in the material incentive fund (the unified material incentive fund), and to independently determine the procedure for paying special bonuses, and their amounts; to reduce bonuses or to not pay bonuses to workers responsible for a worsening of product (job) quality, for violations of production discipline, for failure to comply with standards and specifications, for customer complaints and for return of poor quality products.

The interest of executives and specialists in fulfilling the principal indicators of economic activity is increasing. Bonuses will be paid to them chiefly for 100 percent fulfillment of contracted product sales. Executives in all productive sectors can receive bonuses totaling 13 percent of their salaries. In this case the bulk of such bonuses will be paid for fulfilling planned indicators and raising production effectiveness. The bonus payment procedure in agriculture will remain the same. Personal responsibility for reorganizing wages and introducing new pay conditions is borne by the administration of the association, enterprise or organization.

Control over the progress of measures to improve wages and introduce new pay rates is the responsibility of the ministry and department. It is important in this case to comply with the principle of social justice--equal pay for equal labor. It is the basis of the fundamental wage reform of the 12th Five-Year Plan. The new pay rates and salaries will affect every labor collective in the productive sphere, and it is the task of financial organs that hold audits or conduct specific inspections in businesses they service to reveal available reserves, to offer practical assistance and to maintain constant control over the correctness with which assets are utilized in support of the new pay rates and salaries.

11004
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BRIDGE COLLAPSE REVEALS POOR MAINTENANCE, MANAGEMENT

Moscow PRAVDA in Russian 24 Feb 87 p 6

[Article by Special Investigator Ye. Myslovskiy, RSFSR Procuracy, and Special PRAVDA Correspondent in Vologda Oblast N. Krivomazov: "No One Was Willing to Take Responsibility"; first paragraph is source introduction]

[Text] A bridge at Velikiy Ustyug collapsed: it was unable to bear both its own weight and the neglect of certain administrators.

A new bridge over the Sukhona, designed for 100 years of service, collapsed in its sixth year of life. There were no victims in the disaster; it was a quiet summer night when there was no traffic on it. There was, it's true, one extenuating factor, which the accused parties latched onto, as if grasping at straws; but it fell apart at the first examination. It seems that in this same general area an aircraft flying at 11,000 meters had broken the sound barrier... But aviation is certainly not to blame for the fact that the structure was designed haphazardly: the improperly calculated design of the 63-meter span was already a recipe for disaster.

However, we are not talking about the immediate culprit--the author of the project, who was indicted for criminal liability. While his case is under examination in court, we shall speak about those who, in addition to the designer, also contributed to the disaster--about those who went about their business in a leisurely fashion, trying not to take notice of the minor "imperfections" in their work; who were in fact criminally negligent. In the final analysis, we are talking about the usefulness of instructions. Quite a lot of instructions are being issued these days. There's no denying it: bureaucratic barriers are a hindrance to restructuring. But in a number of cases it is necessary to bring up the subject of the very lack of precise execution of instructions, of official obligations, of following the letter of the law...

L. Mozalev, a former bridge construction worker, contributed the final page in the "history of the disease" of this 6-million ruble structure. In a letter to the city newspaper he asked the city administrators, "Who is in charge of the bridge?" He was offended by the fact that the essentially new structure had the appearance of a sick person.

A commission headed by V. Bobykin, deputy chairman of the Velikiy Ustyug Gorispolkom, reacted rather quickly to the letter. They got together and went out to the site. But in order to properly respond, it was necessary to

examine the bridge from within, to inspect its supporting mechanism. But it turned out to be impossible to get into the interior. For six years no one had looked in there once; they didn't even know who had the key to the entrance. Since they didn't know who was in charge, they simply sawed off the padlock. They wanted to go further, but you see, unfortunately, the interior of the supporting structure was...rather dirty (In six years the mechanism hadn't been cleaned or greased!). And the members of the commission did not wish to trouble themselves with an inspection; what's more there was no light in there. Only V. Grigoryev, a specialist from Bridge Detachment No 61, had the courage to do so, and with the light of a pocket flashlight went inside the bridge. But his remarks about the leakage he discovered--obvious portents of a disaster--were not made a part of the official report. And Bobykin promptly informed the readers of the newspapar SOVETSKAYA MYSL that there was no danger whatsoever.

Less than a month remained prior to the disaster...

Well then, who was actually in charge of the ill-fated bridge? The search for the answer to this question turned into a detective story about the irresponsibility of the responsible persons.

During its first years of operation, the bridge remained on the accounts of the Vologda Highway Construction and Maintenance Administration [Vologda-avtodor], whose chief, V. Meshcheryakov and his subordinate in Velikiy Ustyug, A. Pervuninskiy--in violation of all the rules--did not even set up a maintenance log for the structure, nor did they set up preventive maintenance services for it. After about two years, Meshcheryakov finally persuaded the oblast leaders to transfer the bridge to the municipal services adminstration, due to the fact that one end of the bridge was on city land. His little plan to "shove aside" the bridge--or more accurately, responsibility for it--was carried out in 1982. In violation of existing statutes of the Vologda Oblispolkom, a complicated engineering structure was transferred to the Housing and Municipal Services Administration of the Velikiy Ustyug Gorispolkom, where there was not a single bridge building specialist.

The municipal services people didn't want to take responsibility either, but they had no stomach for a fight with the oblast ispolkom. Therefore, with one hand, N. Bochkarev, chief of the Oblast Housing and Municipal Services Administration, wrote a resolution on the fact that he had neither the funds nor the specialists to operate the bridge--and with the other gave instructions to place the bridge on the account of the city municipal services administration. Bochkarev didn't consider it necessary to inform his ministry of this very costly acquisition, nor did he concern himself with setting up an operating service for the bridge. But they aren't wet behind the ears at the city municipal services administration either: they "shunted" the bridge over to a municipal enterprises combine, and assigned it to the sanitary engineering department. Does a bridge have a lot of needs?

Truly, it did not require very much: just to inspect the interior twice a year, clean out the trash, and grease the supporting mechanisms. It's true, only specialists know about this, but then that's why instructions are

written. And the Vologdites were not deprived of their fair share. Fifty copies of "Operating Rules for Municipal Auxiliary Works" were sent there as early as June 1984. Knowing the importance of this "document," many people wanted to have it, and requested that A. Bubnov, chief of the Production Engineering Department of the Oblast Housing and Municipal Services Administration, send them the instructions. But Bubnov, claiming a shortage of the brochures, turned down the request of even the chief engineer at ZhKKh [Housing and Municipal Services] himself. And when the disaster struck, Bubnov showed the investigators his own copy of the rules, with the notation that they had been distributed in December 1984. Where the remaining copies went is not known. And you see, Bubnov is responsible not only for distributing such instructions, but also for personally monitoring their execution.

A. Voronin and A. Rybin, former chiefs of the Gorispolkom Municipal Services Administration. are convinced that "someone else" is responsible for the bridge. V. Bobykin, gorispolkom deputy chief, believes that someone "from the oblast" should have been responsible for it. And incidentally, N. Bochkarev, chief of the oblast ZhKKh administration, is to this very day convinced that his service did not have the funds for looking after the Sukhona crossing. Although the oblast budget sent to the city up to a half million rubles a year for upkeep, and sent another special allocation of 150,000 rubles during the first year of its transfer to the housing and muncipal services administration, during all its years of operation only 38,000 rubles were spent on the bridge. The savings, we must agree, are absurd!

When a shoemaker bakes a pie, it's a real disaster--and when serious matters are entrusted to incompetents and dilettantes. They not only do not want to, they are unable to work properly. But when the time comes to answer for one's neglect, then feverish activity develops, like the Sukhona at half-flood stage. For example, RSFSR Deputy Highway Minister G. Dontsov tried to prove that construction workers are to blame for the collapse of the bridge, and not poor design engineering. At the same time he did not make a single mention of the fact that the designers did not even carry out calculations of the possibility of an emergency situation. All complaints on this regard were rejected with the assertion that, according to Dontsov, his planning institute is not required to issue instructions on this account, since they are developed by a different department. And then his subordinates began to look for internal contradictions in the technical standards themselves. Only in the final scene of the drama did they admit that, had such calculations been made, the design engineers would certainly have ensured that the required reserve strength had been built in. Such a position hardly supports placing full weight of responsibility on the bridge.

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